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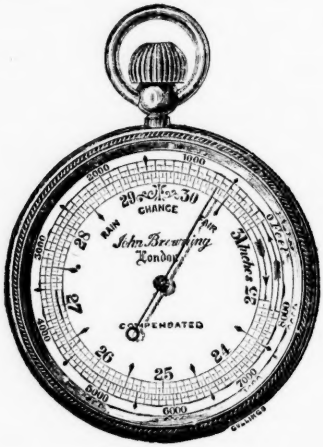

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THE MONTHLY

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OCTOBER, 1879.

I. ON THE TEMPERATURE OF THE SUN.*

By Professor S. P. LANGLEY.

IT is known to all that there is a problem of the highest interest in solar physics at present waiting solution. I mean that of the temperature of the sun; and, so far as the whole radiant energy is inferable from the rate of emission of heat, the problem is one the theoretical solution of which is evidently dependent on our knowledge of the laws of cooling.

Every operation of Nature, whether in the organic or inorganic kingdom, is accompanied by the emission or absorption of heat, and, considering that—whether the subject of observation be the germination of a seed, the heat of a stove, or the outflow from the sun upon the planetary system—we want to know the rate of the deperdition of energy, one might certainly suppose that no physical law would have been better ascertained; but we are here, however (at least in regard to high temperatures), in a state of nearly complete ignorance, and know almost literally nothing about what so intimately concerns us. This is a reproach to modern physics, which has probably made no real advance here since Newton. To justify this language I remark that, in the case of the solar temperature, the *amount* of heat the sun sends us is scarcely in question, as we are all substantially agreed on the way to measure this and on the results of measurement. The latest of these give, it is true, larger values than those of Pouillet, which were about 1·75 calories per centimetre per minute, instead of 2·50; but these considerable variations are so trifling compared with those in the deductions made from them, that we may still say

* A Paper read before the American Academy of Arts and Sciences, October, 1878. Communicated by the author.

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there is substantial agreement as to data. From like data, then, Sir John Herschel concludes that the temperature of the solar surface is over 5,000,000° C.; Mr. Ericsson, whose labours on this point deserve wider recognition, is confident that the temperature is not materially different from 4,000,000° F.; Father Secchi, in his latest research, makes it 133,000° C.; Sir Wm. Thomson and others estimate 30,000° to 60,000° C.

These extremely gross discrepancies having drawn general attention, many distinguished French physicists have lately re-investigated the subject, and, using Dulong's and Petit's formula, have after most elaborate research arrived at the nearly unanimous conclusion that the temperature of the solar surface is altogether lower than any of these,—is in any case not more than 2000° to 2500° C., but is more probably below than above the temperatures which are reached in our furnaces, and in fact is probably less than that of melting platinum.

It is here to be borne in mind that we really know nothing about the absolute emissive capacity of the solar surface, and that to simplify the problem, when we speak of the sun's being at a lower temperature than that of a certain lamp-black surface or hot platinum or steel, it is assumed, for the purpose of comparison, by myself as well as by the above-named investigators, that both the solar and terrestrial sources of heat have the same emissive capacity. The temperature thus defined has been called the "effective" temperature.

M. Violle, one of the most distinguished students of the subject, whose experiments bear evidence of intelligent care, found by observations at Grenoble, in March, 1874, that, with an emissive power thus defined, the temperature of the solar surface was 1230° C.* In a subsequent memoir he finds for the same the rather higher value of 1354° C.† After allowing for absorption in our atmosphere, it remains true that the temperature is then much below that of melting platinum, and this seems to be confirmed by his later results, which give about 1550 C. as the highest "effective" temperature.

All these and other observations involve the use of the empirical formula, well known as that of Dulong and Petit, which has replaced the earlier and simpler one of Newton.

Now, whatever be the apparent presumption of opposing my opinion to that of so many conscientious and recent

* Comptes Rendus, vol. lxxxviii., p. 1425.
† *Id.*, p. 1816.

investigators, I feel there is something yet to be said; and the present paper is an account of experiments of a special character, undertaken at the expense of the Rumford fund, not with the hope of at once solving so arduous a problem, but with the wish, in this confusion of opinion, to contribute one or two incontrovertible facts as material towards the construction of future theory. I hope to show convincingly that the sun's "effective" temperature is, at any rate, far above that of any ordinarily attained in the arts (very much above that of melting platinum for instance), and incidentally that the law of Dulong and Petit is untrustworthy precisely where we need to apply it.

If we have no formula by which to infer the temperature of the sun, there remains the comparison of its radiation with that of a terrestrial source of high *known* temperature. Thus the late Father Secchi has measured the radiation from the electric arc, and M. Violle that from a Siemens-Martin's furnace; but, by comparing these only with others made at other times on the sun, discrepant results appear also. Were we, however, to compare the sun *directly* with a terrestrial source of high temperature, and bringing them face to face find one giving more heat than the other, there could (with equal emissive powers) be no question but that the body radiating more heat was also the higher in temperature. Strange to say, this simple test has never, that I know, been applied to this problem* until in the experiments I am about to describe.

We have in the arts one process which gives what we want ready to hand in the production of a vertically disposed surface of several square feet of a liquid metal, hotter than melted platinum itself. I refer to the Bessemer process now in use in several places in this country, among others at the Edgar Thompson steel-works, about twelve miles from Pittsburg. I have received every possible assistance from the managers of this great establishment, and owe my acknowledgments here for their kindness.

As the Bessemer process may be as vaguely known to some as it was till lately to me, I will first briefly describe so much of it as concerns the present purpose.

An enormous egg-shaped vessel called the "Converter," capable of holding 30,000 to 40,000 pounds of melted metal, is swung on trunnions so that it can be raised by an engine to a vertical position, or lowered so as to pour its contents into a cauldron. First, the empty "converter" is inclined,

* Experiments with the lime and electric lights made for other purposes are not here in question.

and into its mouth is poured about 15,000 pounds of fluid pig-iron, whose temperature as it flows in from an adjacent furnace, where it has previously been melted, is about 1400° C. Then the "converter" is lifted to an erect position, and an air-blast from a powerful blowing-engine is forced up through its liquid contents. In the 15,000 pounds of impure iron there are ordinarily found about 230 pounds of silicon and 540 of carbon; and as each pound of carbon gives 8,000 calories, and each pound of silicon 12,000 to 14,000, in connection with the air-blast's unlimited supply of oxygen, the temperature of the already molten metal rapidly rises under this enormous inflow of several million calories of heat. After the blast has continued eighteen to twenty minutes, the temperature of the contents is from 1800° to 2000° C., or higher than that of melted platinum, taking the lowest estimate; and now the "converter" is again lowered, and about 1500 pounds more of melted iron added. The temperature here, perhaps, falls slightly, but its effect may be judged by any one who sees this second lot of iron poured in. Melted iron by itself, every one knows, seems dazzlingly bright; but as this streams into the open mouth, the interior is so much brighter still, that the stream is deep-brown by comparison, presenting a contrast like that of dark coffee poured into a white cup. The contents are no longer iron, but liquid steel ready for pouring into the cauldron; and, looking from in front into the inclined vessel, we see the almost blindingly bright interior dripping with the drainage of the metal running down its sides, so that the circular mouth, which is twenty-four inches in diameter, presents the effect of a disk of molten metal of that size, were it possible to maintain such a disk in a vertical position. In addition, we have the actual stream of falling metal which continues nearly a minute, and presents an area of some square feet. The shower of scintillations from this liquid cataract of what seems at first "sun-like" brilliancy, and the immense area whence such intense heat and light are for a brief time radiated, make the spectacle a most striking one.

Platinum dipped in the steel as it pours from the lip melts away; and not to rely on this evidence, which might be alleged to be due to an alloying rather than a true melting, I procured some platinum wire which Mr. Preusser, the chemist of the works, stretched, at my request, across the open mouth of the "converter" when in an erect position. The platinum, here several yards above the metal, was melted by the blast which came from it.

Heat Comparisons.

After many visits to the works, much trouble and repeated failures due to the difficulties of working in such novel circumstances, I secured a series of trustworthy measures, in May last, both of heat and light. I describe my apparatus here in principle, not in detail; and I omit many preliminary experiments, as well as some minute corrections applied for small instrumental errors, giving my results in general terms. One difficulty attending a simultaneous comparison was to obtain a station looking into the "converter" at the time it was inclined and pouring, and yet necessarily outside the building in the sunlight. To do this, I stood in a window (whence the sash had been removed) of the west wall, sixty-one feet from the "converter" mouth. A platform was erected here for my apparatus, part of which was clamped to the wall itself; but though this was the best point of observation, the noise, the shower of sparks driven over the instruments from within by the blast at each "pour," and the rain of wet soot without which fell thick at times on apparatus and observer from the combined steam and smoke of adjacent chimneys, made the task of observation another thing from what it is in the quiet of a physical cabinet.

From this window-station, a *porte-lumière* reflected the sun's rays, so that traced through the dusty air the beam was seen to enter the "converter" mouth, or fall on the stream which ran from it. In the path of this beam was a cylinder, containing within a double enclosure an Elliott thermopile of forty small elements, similar to that I had used for some years on the sun, and surrounded by all the precautions against air-currents and extraneous influences taught me by experience. The pile exposed both faces at once, one to the furnace, the other to the reflected sunbeam; and a Thompson reflecting galvanometer read by an assistant, and placed at a considerable distance from any moving iron, gave prompt evidence as to which face was hotter.

The angular area, subtended at the pile by the fluid metal, was always many times that subtended by the sun's disk, and there was no lens or medium of any kind (except air) between the "converter" mouth and the pile. Supposing, then, the metal to have only presented a disk equal in angular diameter to that of the sun, if the needle remained stationary, it is plain that each was sending an equal amount of heat, and that any square foot of the solar surface was

radiating at least as much heat as a square foot of the metal; for it is obvious that the distances of the two sources have nothing to do with this effect under the given conditions.

The metal area, however, being many times that of the sun, the latter still over-balanced the metal; showing that the sun was actually very much the hotter. Accordingly, there was interposed between the *porte-lumière* and the pile a telescope which diffused the sun-light over an image of any given diameter. As the solar light entered only through a diaphragm of known dimensions, it was easy to say how much the sun's heat was weakened to balance that from the metal. It must be borne in mind, however, that there was no account taken of the loss of solar heat by reflection and absorption in the lenses, by reflection from the mirror, and more than all by the frequent clouds of smoke and steam, while the furnace heat suffered no diminution whatever. Further, every other condition of the experiment was designedly such as to weigh in favour of the furnace and against the sun's heat. The value found for the latter, then, is a minimum value. I should, perhaps, have remarked that experiments had shown that the trifling heat from objects near the melted metal might be neglected. That from the atmosphere about the sun was also insignificant. Except, then, for the diminution of solar heat by absorption, reflection, and so on, our method is equivalent to bringing a specimen piece from the sun's surface (if I may so express myself) face to face with one from the furnace, placing our thermopile mid-way between them, and determining how much we have to diminish the size of the former to make its heat-radiation no more than equal the latter's.

The result of these experiments was that the minimum value we can assign to the solar radiation is eighty-seven times that from an equal area of the pouring metal. This, it will be remembered, is not an actual but a minimum value. The true value may be indefinitely greater.

Photometric Comparisons.

Of the complex radiations from any source of high temperature, a part is interpreted by the pile as heat, a part by the eye as light; but as the temperature is raised, it is now well known that the waves of shorter length increase in amplitude much faster than the longer ones. If the temperature of the sun, then, be much greater than that of

the furnace, we shall have a quite independent proof of the fact in a photometric comparison, which, we can safely pronounce *a priori*, will then give a very much greater ratio of sunlight to furnace-light than that of sun-heat to furnace-heat. To make this comparison, a photometer box, about 8 inches in square section and 66 inches in length, is placed so that its central axis lies as before in the path of the reflected beam from the mirror to the furnace. Two similar telescopes of 1·66 inch aperture and 20·01 inches focus, having their objectives outside the extremities of the box and their optical axes in the path of the beam, project, by their eye-pieces, images of the sun and of the pouring metal on the two sides of a Bunsen disk, whose normal position is in the centre of the box. Both images are viewed simultaneously by mirrors attached to the disk, which is movable along a graduated scale. (I here omit certain small corrections applied in practice, and describe the use of the instrument in brief terms.) We do not now need to consider the relative angular areas of the sun and furnace, for so long as both are of appreciable size the images of both falling on the screen, when nearly midway between the two telescopes, will be sensibly proportioned in brightness to the absolute intensities of the sun-light and furnace-light. We do, in fact, however, at the outset find the sun-light so immensely brighter that no direct comparison is possible. We then diminish the aperture of the solar telescope (which we will call A), till it has a small known ratio to that of the furnace telescope (which we will call B). In practice B was always left with the full aperture of 1·66 inch diameter, while that of A was 0·192. Were the original sources of equal intensity, the sun-light would have been reduced to $\left(\frac{0{\cdot}192}{1{\cdot}660}\right)^2 = 0{\cdot}013+$ or a little over one one-hundredth of the other. But it was surprising to see that the image from A was even now incomparably stronger than that formed either by the flame from the blast at its brightest, or by the pouring metal. Under these circumstances, the Bunsen disk was moved from its central position toward B, thus approaching the apex of one light cone and withdrawing from the other, so as to diminish the sun-light still further in an exactly determinable ratio. The lowest value obtained in a series of accordant measures gave intensity of sun-light over (5300) five thousand and three hundred times that from the metal; and this value is, I think, considerably below the truth.

It results from these experiments: (1) That direct observa-

tion disproves the statement that the sun's effective temperature does not exceed 1500° C. It is demonstrably over 1800° C., and may for anything here shown to the contrary be indefinitely greater.

(2) The solar heat-radiation, so far from being comparable to furnace heat, is at a minimum something like 100 times that from melted platinum, area for area, and probably much greater.

(3) The solar-light radiation (which offers a more trustworthy indication of the total difference between the sum of all degrees of radiant energy than the heat) is over 5300 times that from a temperature above that of melted platinum.

(4) Since all the above results are simple statements of the facts of experiment, and are independent of formulæ, we conclude that the formula of Dulong and Petit (which from well-conducted experiments, like those of M. Violle, deduces conclusions which trial disproves) must be itself wrong. Further, since this formula contains no term depending on the wave-length, it takes no account of the difference here proved to exist between the relative quantities of heat and light radiation from sources of high temperature, and is thus found especially untrustworthy at those temperatures at which it has been most frequently applied.

I do not yet venture an opinion of my own on the real temperature of the sun, further than that I think it much higher than has been of late believed.

The preceding observations and inferences all seem to point to the use of the highest attainable terrestrial temperatures (*e.g.*, that of the electric light) in comparisons (and the consequent least dependance on formulæ) as the safest line for future investigation.

II. SCIENTIFIC MATERIALISM AND ULTIMATE CONCEPTIONS.*

UNDER the above title Mr. Sidney Billing has issued a work which even those who dissent most widely from the author's views will find, we think, worthy of a careful examination. Its main features are a vigorous critique of scientific materialism as expressed more or less overtly in many works and speeches of the present day, and especially in the famous "Belfast Address" and "Birmingham Oration" of Prof. Tyndall; a protest against the license of so-called "scientific imagination" and against the dogmatic intolerance—shall we say of official science? Lastly, the author calls in question the received theory of heat as a molecular and ethereal vibration, and suggests that it should be regarded as a substantive entity, "the primordial unity out of which matter arose," the principle of all terrestrial phenomena, but itself a product of intelligence. These three questions are not discussed separately and seriatim, but are interwoven together, and accompanied by utterances and reflections on a great variety of subjects, which, if not always strictly relevant to the main issues, are often highly original and suggestive. As an instance we extract the following note:—"The red-skin hunter hoped to be translated to a region abounding in game. The Maori believed that life after death is a series of skirmishes in which the blessed are always victorious. The Teuton of old nourished the same hope. Civilisation cramps such aspirations. Would the cotton-weaver be content to labour for ever in cotton-mills, even though they were miles upon miles in length?"

Mr. Billing brings to his task an amount of erudition which we must pronounce wonderful. He has read and has at command not merely scientific and quasi-scientific, but non-scientific and even anti-scientific, works. Carlyle, Fichte, Bruno, Spinoza, Lucretius, Hume, Cousin, Radcliffe, and Noah Porter are as familiar to him as Humboldt, Liebig, Kekulé, Helmholtz, Darwin, Du Bois-Reymond, or the "Bridgwater Treatises." We find, however, no sign that he is an experimentalist or observer in any branch of

* Scientific Materialism and Ultimate Conceptions, by SIDNEY BILLING. London: Bickers and Son.

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science. For a further understanding of his position we may remark that he is an Evolutionist—though somewhat encumbered with teleology—and an admirer of Darwin. Though a stout opponent of what is called "materialism," he is far from identifying himself with any of the creeds. Hence every man's hand will be against him. He has blasphemed South Kensington in the person of some of its chiefs, and has failed to conciliate Exeter Hall and the tea-tables.

As far as regards his denial of the dogma that in matter we have "the promise and potency of every form and quality of life," we are with him heart and soul. Nor can we dissent from him when he enters his indignant protest against the part now played in science by imagination, in the absence of demonstration. Philosophers have in former days denounced the credulity of religionists. Alas! it is to be feared that in our time the authorised expounders of science make larger demands on the unreasoning faith of their hearers than did ever the apostles of a new religion. When we overlook the field of human knowledge, and consider how much is assumed and how little is really established, we are seized with a deep sadness. Nor is this scientific faith genial and tolerant. It is too true, as the author quotes from Prof. Kekulé, that all "who sin against these dogmas are persecuted as heretics." Said Professor Tyndall in his much discussed Belfast Address:—"There is in the true man of science a wish stronger than the wish to have his beliefs upheld, namely, the wish to have them true, which causes him to reject the most plausible support if he has reason to suspect that it is vitiated by error." These are brave words; but though the accepted theories of heat and of light are admittedly not free from difficulties, how many physicists could be found willing to submit such theories to a full re-consideration, and to weigh the arguments in favour of the hypothesis which our author seeks to revive? Nay, what is the reception met with by an experimental fact which seems to point in some heterodox direction?

Mr. Billing, who takes for his motto the sober watchword of Du Bois-Reymond, "*Ignoramus—Ignorabimus*," compares with the thoughts which it embodies certain other phases of German speculation as brought popularly forward in the "Munich Addresses" of Nägeli, Haeckel, and Virchow. The first of these worthies, who for our tastes is far too sanguine in his expectations of what scientific certainties we may yet attain, proposes as a counter-cry "We know,

and shall know, if we be content with human insight,"—a saving clause capable of exceedingly wide application. As to Prof. Virchow, we distrust him. His ostensible watch-word, as here quoted, is "That which honours me is a knowledge of my own ignorance;" his esoteric motto is said to be "Restringamur," *i.e.*, academic freedom, and, probably, the liberty of the author as well as of the professor. The charge brought against him, that he is intriguing to eject all Evolutionists from their chairs in the German universities, has not been formally demonstrated, but it is strongly countenanced by the following language which he has undoubtedly used:—"I only hope that the theory of Descent may not bring all those horrors in our country which similar theories (!) have actually brought to our neighbours. Anyhow this theory, if carried through to its consequences, has an extremely dangerous side, and that the Socialists have a certain notion of it already you will doubtless have remarked." We will not dictate to Mr. Billing what estimate to form of the man who makes this artful and disingenuous attempt to excite the *odium politicum* against a theory which he dislikes. In spite of his well-known abilities Prof. Virchow might feel somewhat puzzled if bound to name the "similar theories" which have given rise to "horrors" in France. If he really believes what he here professes he can scarcely have taken the trouble to examine what the tendencies of Evolutionism truly are, and his "knowledge of his ignorance," before it can throw any great honour upon him, will require to be supplemented. Were this the legitimate sphere for such a discussion it would be easy to show that the doctrine of Descent points in a direction the very opposite, and is flatly antagonistic to not a few of the leading principles of "social democrats" and "advanced political thinkers." This task, however, has been ably executed by Prof. Oscar Schmidt, to whose memoir we refer the reader.

The author's criticism of the Belfast Address and the Birmingham Oration, able as it must in many respects be pronounced, comes too late. We cannot help, however, noticing that the story of the "merchant convulsed into action by a telegram," quoted by Prof. Tyndall from Lange, points in reality to one of the most powerful arguments against the materialistic (somatic) theory of life A man is, we will suppose, at dinner with a brisk appetite. Suddenly he receives—whether by letter, telegram, or verbal message it matters not—some alarming message. A dear friend may have been taken dangerously ill; or a litigious

idiot, of whose very existence he was ignorant, may have brought against him an action for libel. What is the result? His appetite is gone, and all the ordinary symptoms of indigestion come on. Yet for all this there is no physical cause. No material substance has been introduced into or withdrawn from his system. No "force," using the word in its ordinary sense, acts upon him in a different way from what it did previously. A purely immaterial something, a piece of intelligence, has acted upon him like a dose of poison. That such psychic poisons—if we may be allowed the expression—can even prove mortal the annals of medical science fully show.

These considerations bring us to one of the points on which we have not the pleasure of agreeing with Mr. Billing; we refer to his disposition to draw what to us appears far too absolute a boundary-line between man and the lower animals. It is superabundantly proved, as far as testimony can prove anything, that in brutes, also, ill health —chronic or acute—may be occasioned by purely immaterial causes, such as fear or distress.

The author's assumption that the intelligence of the lower animals is "not that of an individual, but of the whole species," is flatly contradictory to the experience of all who have taken trouble to observe closely and fairly. Between different individuals of the same species, and even of the same race, there occur the most manifest differences in mental power. One dog hits upon devices and stratagems to secure his ends which never strike another. One spider will ballast its web in stormy weather with, *e.g.*, a chip of wood, whilst other spiders of the same species, with the same facilities and under identical circumstances, do no such thing. Mr. Billing, we are sorry to perceive, goes the length of ascribing cases of animal intelligence to an error on the part of the observers. In other words, he refuses to admit facts contrary to his prepossessions. The assumption of an "innate potence" distinct from reason, and yet fulfilling the tasks of reason, is in truth a desperate attempt to uphold a decaying error.

The extent to which our author's science is diluted with "Bridgewater" is also to be regretted. We demur altogether to the fundamental assumption of teleologists that God's purposes are known to mankind; nor would it be hard to show, from indisputable facts, that if a maximum of earthly happiness for man had been His object, the world would assuredly have been constituted very differently from what it now is. Teleologists have been challenged to

produce a new Bridgewater Treatise having for its theme the mosquito, the chigo, the *Lucilia hominivora*, the trichina: but they have prudently held back.

Bell is quoted as saying that "Canine teeth accompany a carnivorous appetite and boldness of disposition; boldness, fierceness, and cunning accompany retractile claws and sharp teeth." The truth is, however, that canine teeth are splendidly developed in the non-carnivorous gorilla, and are absent in the bold and aggressive buffalo; whilst in "boldness, fierceness, and cunning" the Canidæ and the Ursidæ, which have not retractile claws, do not fall short of the cats. Galen is incorrect if he says that the eaglet will attempt to fly when first freed from the egg-shell; it will sit helplessly waiting to be fed.

But space will certainly not permit us to enter upon the minute discussion of Mr. Billing's biological views, which to the present writer, as an old naturalist, seem the weakest part of an otherwise most valuable and interesting work.

The author not merely admits the high antiquity of the human race, but suggests the possibility of a high civilisation having been attained in times of which no written record has survived. "It is possible," he says, "Suleiman and the pre-Adamite kings, with their attendant genii, were traditional allegories of knowledge and power, and it may be the dwellers on the earth had compassed a knowledge thousands and thousands of years before the so-called historical era, and far exceeding that pourtrayed or which science conceives." All this *may* be, but we can at present merely guess, and not prove.

Two passages seem to us to convey a grave and needed warning. "A nation actuated alone by moral law, with conscience as a regulator or administrator, could not exist beside other nations impulsed by a lower ideal, because it would be the prey of instinctive rapacity."

The following reflection may be taken to heart by us all: —"So enslaved is the general mind by the authorities of the time that it is assumed to be treason to doubt the dicta of the leaders of the day, talk what or how they may—absurdities become logic; sensationalisms, eloquence; suicidal fanaticism, patriotism; and prose run mad, poetry; all because at some time in their era they have earned a name for *some themes logically reasoned, for some experiments successfully conducted, for some political conduct ably directed, and for some poems admirable and artistic.*"

We hope our readers will make personal acquaintance with a work which we would gladly have noticed in a style less hasty.

III. EXPLOSIONS FROM COMBUSTIBLE DUST.*

By Prof. L. W. Peck.

I WISH to demonstrate to you this evening, by a few simple experiments, the fact that all combustible material, when finely divided, forming a dust or powder, will, under proper conditions, burn with explosive rapidity.

If a large log of wood were ignited it might burn a week before being entirely consumed; split it up into cord-wood, and pile it up loosely, and it would burn in a couple of hours; again, split it into kindling-wood, pile loosely as before, and perhaps it would burn in less than an hour; cut it up into shavings and allow a strong wind to throw them into the air, or in any way keep the chips comparatively well separated from each other, and it might be entirely consumed in two or three minutes; or, finally, grind it up into a fine dust or powder, blow it in such a manner that every particle is surrounded by air, and it would burn in less than a second.

Perhaps you have noticed that shavings and fine kindlings will sometimes ignite so quickly in a stove that the covers will be slightly raised, the door forced open, or perhaps small flames will shoot out through the front damper. You have, in such a case, an explosion on a very small scale similar to that of the Washburn, Diamond, and Humboldt Mills of this city, on the night of May 2nd,—upon which occasion the rapid burning of hundreds of tons of flour, bran, &c., completely demolished the solid masonry walls (6 feet thick) of the mills, and threw sheets of iron from the roof of the Washburn so high into the air that they were carried 2 miles by the wind before striking the ground.

Let us now see why such explosions occur. Wood has in it a large amount of carbon, the material of which charcoal is composed, and the air is about one-fifth oxygen. Now, at the ordinary temperature, the carbon of the wood and the oxygen of the air do not combine; but when they are heated —as by friction, concentration of the sun's rays, chemical action as from a match, or in any other way—they combine to form carbonic acid gas. This chemical action produces a large additional amount of heat, which keeps up the action as long as there is any carbon and oxygen left to unite, and

* Lecture delivered June 1, 1878, at Association Hall, Minneapolis, Minnesota, at the request of the millers of the city.

also makes the temperature of the gas which is formed very high.

As the space occupied by the carbonic acid gas and that occupied by the oxygen which entered into the combination is the same at the same temperature, there would be no bursting if, after combination, the temperature were the same as before; but it is a fact, which you have all observed, that fuel in burning produces heat: it is also a fact that heat expands a gas, and it is this great amount of heat, taken up by the carbonic acid formed, that produces the immense pressure in all directions.

Let us return to our log of wood. There is exactly the same amount of heat and carbonic acid produced when complete combustion takes place in each of the cases of burning, the only difference being as to time. In the first case, the explosion or pushing aside of the surrounding air occupies a week, in the last only a second.

Snow-flakes fall gently upon your shoulders, and you are required to perform an insensible amount of work to resist the crushing effect of each flake; but suppose that all the snow that has fallen upon your head and shoulders for the last ten years was welded together in one solid mass of ice, weighing perhaps one hundred pounds, and that it should descend with the velocity of a snow-flake upon you, an immense effort would be required to prevent its crushing you, even if you were able to withstand the shock at all. The work of many days would be concentrated into an instant.

So it is with burning wood: four or five cords of wood and a large stove will give you a roaring fire all winter; the work done is manifested by the heat obtained, by the rushing of hot gases up the chimney, and of air from outside into the room through every crack. But if the wood were ground into a powder and scattered through all the house, and burned instantly, the cracks, doors, windows, and flues would not be sufficient to give vent to the hot gas, and the roof and sides of the house would be blown to pieces.

What is true of wood is also true of grain; also of vegetables, with their products when they contain carbon, with this exception—grain, either whole or ground, will not burn readily when in bulk. A fire could be built upon a binful of flour, and kept burning for half a day without igniting the flour; it would char upon the surface, but it lies in such a compact mass that the air does not get access to it readily; hence it does not burn.

I wish to show you now how combustible dust will burn

when blown into the air by means of a pair of ordinary hand-bellows.

I have here two boards, about 12 by 18 inches, nailed together, forming a V (*see* Fig. 1). Just outside of the V an

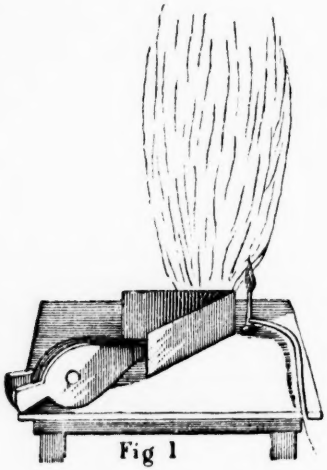

Fig 1

ordinary Bunsen gas-burner is placed, and within is a small handful of dust taken from a sash and blind factory. Upon blowing it smartly with the bellows a cloud is formed about 15 feet high,—extending, in fact, to the ceiling,—which ignites from the lamp and produces a flash, very quick and exceedingly *hot*, resembling very much a gunpowder flash. You will notice that a large amount of dust falls from all around the edge of the flame without burning; that is because it is not thick enough. Two things are necessary: first, that each grain of dust be surrounded with air, so that it can get the oxygen required *instantly;* and, secondly, that each grain shall be so near its neighbour that the flame will bridge over the space and pass the fire from particle to particle.

I think, after seeing the immense flame produced by such a small amount of fine saw- and sandpaper-dust, you will no longer wonder at the rapid spread of flames in furniture and similar factories. You know it is practically impossible to put out a fire after any headway is attained in these establishments; the draught produced will blow all the dust from walls and rafters into the air, and the building in an

instant is a mass of flame. Perhaps many of you remember the fire in the East-Side Saw-Mills, a few years ago. Large masses of fine sawdust had probably collected upon the rafters, and the whole roof was perhaps filled with cobwebs loaded down with dust. A fire started from one of the torches used, and shot through the mills with lightning-like rapidity, and save for the fact that the ends and sides of the building were all open, there would have followed an explosion like that at the flour-mills. As it was, the men had very great difficulty in escaping with their lives, notwithstanding that a short run in any direction would have taken them out of the mill.

It is very evident that too great care cannot be taken to keep all such factories and mills as free from dust as possible.

I will now blow some ordinary starch into the air in the same way, and you notice the flame is more vivid than in the last experiment, and if you were in my position you would notice that the heat produced is much greater. Notice now that this powdered sugar burns in the same way.

You will see, from the experiments further on, that three-quarters of an ounce of starch will throw a box, weighing 6 lbs., easily 20 feet into the air, and that half an ounce

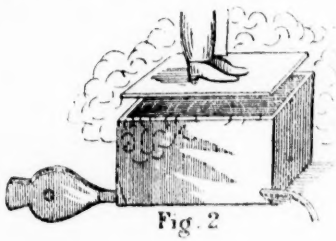

Fig. 2

burned in a box will throw up the cover 3 inches with a heavy man standing upon it.

With these facts, which I have demonstrated before you, no one need regard as a mystery the Barclay Street explosion in New York city, where a candy-manufactory, in which large amounts of starch and sugar might in many ways be thrown into the air by minor disturbances, took fire, and completely wrecked a building and destroyed many lives.

I will now burn in the same way some buckwheat, which, as you will observe, gives a very large blaze; now some corn-meal, which is too coarse to burn as well; now some rye-flour, which burns much better than the corn; now

some oatmeal, the finer part of which only burns; and so I might continue with all sorts of finely-ground vegetable material.

Let us take up now the products of the manufacture of flour from wheat. There were between 300 and 400 tons of these materials, upon which I am now to experiment, in the Washburn Mill at the time of explosion, and there was a corresponding amount in the Diamond and Humboldt Mills, which, by their sudden burning, produced the second and third shocks heard directly following the explosion of the larger mill.

The wheat is first placed in a machine, where it is rattled violently and brushed. At the same time a strong draught of air passes through it, taking all the fine dust, straw, &c., and conveying it through a spout to a room known as the wheat-dust room, or perhaps more commonly it is blown directly out of the mill.

You see some of this material here; it looks like the wood-dust of the first experiment, and, as you see, burns with a quick and sudden flash when subjected to the same conditions.

Here, then, we have the first source of danger in a flour-mill. A thick cloud of this dust, when conveyed through a spout by air, will burn in an instant if it takes fire; and if there is any considerable amount of dust, as there would be if there were a dust-room, an explosion will follow which may become general if it stirs up a thick dust-cloud throughout the mill.

The wheat, after it has been cleaned in this way, goes to the crushers, which are plain or fluted iron or porcelain rollers, working like the rollers in a rolling-mill. The object of these rollers is, I believe, to break off the bran in as large pieces as possible, and to crush out or flatten the germ so that it can be separated with the bran from the rest of the meal.

The crushed wheat goes now to the stones, where so much heat is produced (average 135° F.) that a large amount of steam is formed from the moisture in the materials. This steam would condense in the meal, and interfere with bolting, &c., if it were not removed. To effect this another draught of air and another spout are employed, and, as might be expected, this current takes a large quantity of the very finest flour, called flour-dust, with it. To save this a room is provided near the end of the spout, called the flour-dust house. The spout conveying steam and dust enters this room on one side, and another spout opposite leaves it,

passing to the open air. It is in this comparatively dead-air space that the dust settles, and can be collected from the floor. Here is some of this material, which, as you see, when blown into the air, produces a vivid flash, extending from the table to the wall.

The evidence taken before the coroner's jury shows very clearly that it was this material that started the great explosion of May 2nd. Just how the mill took fire will probably never be known, of course, but in all probability the stones either ran dry—that is, were without any meal between them—or some foreign substance, such as a nail, was in the feed, producing a train of sparks such as is produced by an emery wheel or a scissors-grinder's wheel. These sparks set fire to small wads of very hot dust, which, as soon as they were fanned into a blaze, communicated it to the spout and house full of dust. An eye-witness of the explosion first saw fire issuing from the corner of the mill where this flour-dust spout was situated, the end of the spout having probably been blown out. This fire was followed instantly by a quick flash, seen through all the windows of the floor upon which the flour-dust houses were situated, followed instantly by a flash in the second story, then the third, and, in rapid succession, fourth, fifth, and sixth stories; then followed the great report produced when the immense stone walls were thrown out in all four directions, and the roof and part of the interior of the mill shot into the air like a rocket.

It would seem that a blaze is necessary to ignite the mixture, for I have tried powerful electric sparks from a machine and from a battery of Leyden jars; also incandescent platinum wire in a galvanic circuit, and glowing charcoal, without producing any fire, however thick the dust might be. Perhaps, however, under more favourable conditions the dust would ignite directly from sparks, but it seems very improbable.

Let us continue now with the process through which the ground wheat is made to pass. From the stones it is conveyed to the bolting-reels, where the very finest is sifted out first, and we obtain a grade of flour; after the finer material is sifted out it goes to a coarser bolt, where the "middlings," as it is called, passes through, leaving the bran which comes out at the end of the reel. The middlings, as it comes from the bolts, has fine bran and dust in it, and, to purify it, it is subjected to an operation similar to that of cleaning the wheat,—that is, in the middlings purifiers it is subjected to a draught of air which takes away all the light bran and

dust, leaving the heavier material (purified middlings), which goes again to the stones to be ground into flour,

Here is some of the dust from these "middlings-machines;" you observe it burns as the other materials burned, quickly, and with intense heat.

Here is some of the purified middlings; each grain is comparatively large and heavy, making it difficult to blow it well into the air, but, as the blaze produced by each particle is quite large, a flash is produced which does not differ materially from the others.

Here is some of the general dust of the mill,—that is, dust swept up from the floors, walls, beams, &c. You will see it acts in all respects like the other substances.

And, finally, here is some of the flour taken this afternoon from the flour-sack at home; it burns, you observe, if possible with even more energy than the other kinds of dust.

I have performed a few experiments, which I will now repeat, which will illustrate to you the immense power that these materials exert when burned in a confined space.

This box (Fig. 2) has a capacity of 2 cubic feet; the cover has a strip 3 inches deep nailed around it, so that it telescopes into the box: there is in this lower corner an opening for the nozzle of the bellows, in this an opening for the tube to the lamp. I place now a little flour in the corner, light the lamp, and my assistant places the cover upon the box and steps upon it. Take notice that upon blowing through the hole, and filling the box with a cloud of flour, the cover comes up suddenly, man and all, until the hot gas gets a vent, and a stream of fire shoots out in all directions.

Here is a box (Fig. 3) of 3 cubic feet capacity, including this spout, 9 inches square and 15 inches long, coming from the top of it; at the ends doors are arranged closed like steam-boiler man-holes; openings for light and bellows are arranged as in the previous box.

Here is a box, weighing 6 lbs., that will just slip over the spout; it has a rope lest it should strike the wall after the explosion. Placing now the lamp in the box, some dust in the corner, and the box over the spout, we are ready for another explosion. You observe, after blowing vigorously for a second or two, the dust in the box takes fire; the box over the spout is shot off, and rises until the rope (about 12 feet long) jerks it back; it strikes the stage with great force, rebounds, and clears the foot-lights, and would strike the floor below were it not for the rope.

I have thrown a box similar to this in the open air 20 feet

high, while, as we shall see presently, less than an ounce of flour is being consumed.

I have fastened over the top of the spout five thicknesses of newspaper: upon igniting a boxful of dust as before, the paper is thrown violently into the air, accompanied by a loud report as it bursts.

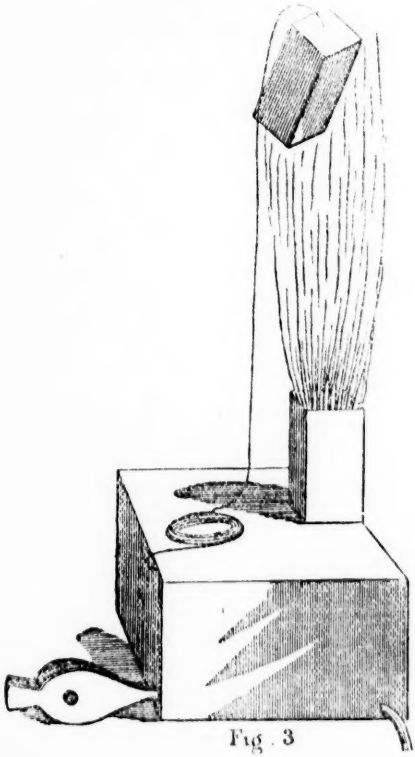

Fig. 3

For the last experiment I have a box of 4 cubic feet capacity (Fig. 4); five sides are $1\frac{1}{2}$ inches thick, the remaining side $\frac{1}{4}$ inch. Upon igniting the dust in this box, filled as in the other cases, the quarter-inch side bursts, and a stream of fire shoots out half-way across the stage.

One lb. of carbon and $2\frac{2}{3}$ lbs. of oxygen, when they combine to produce carbonic acid, will evolve heat enough, if it

were applied through a perfect heat-engine, to raise 562 tons 10 feet high; if, therefore, 40 per cent of flour is carbon, it would require $2\frac{1}{2}$ lbs. to accomplish this result, if an engine

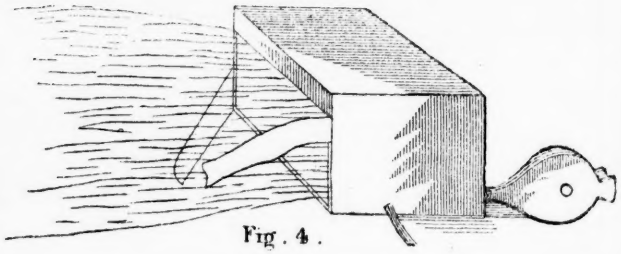

Fig. 4.

from which there would be absolutely no radiation, conduction, or loss of heat, in any way, were a practical possibility. Let us see how much air would be required to supply oxygen enough. Under ordinary conditions every 100 cubic inches of air contains 7·13 grains of oxygen, from which we find that $151\frac{1}{2}$ cubic feet of air would be required for the $2\frac{2}{3}$ lbs. of oxygen. Hence the $2\frac{1}{2}$ lbs. of flour must be equally distributed as a dust through $151\frac{1}{2}$ cubic feet of air, in order to produce the most powerful result.

If 41 ounces of flour require 151 cubic feet of air for perfect combustion, 1 cubic foot of air will supply oxygen enough for $\frac{41}{151}$ of an ounce of flour. Hence our box, which lifts the man so readily, burns $\frac{1}{2}$ ounce of flour or less; and the other, which throws the box into the air, $\frac{3}{4}$ of an ounce, unless, as I think quite probable, an additional amount of air is drawn in through the cracks as soon as the vent is opened at the top of the box. In fact these experiments work better if a few small holes are made near the bottom of the boxes.

It may be worthy of mention here, as a point of interest to insurance companies, that in all dust-explosions a fire precedes the explosion in every case. The dust must burn before the heat that produces the immense expansive force is generated.

Too great precaution cannot be taken in all kinds of manufactories, where combustible dust is produced, against fire, especially in those establishments where it is conveyed in thick clouds by air-draughts through spouts and rooms.—*Popular Science Monthly.*

IV. ANOTHER VIEW OF THE ANTIQUITY OF MAN.

By Prof. B. F. MUDGE, Manhattan, Kansas.

WE were much interested with the article in the June number of the "Review" on the Antiquity of Man, by the Rev. J. L. Templin. He has very clearly and fairly stated the facts in the case, though we think he has left the question of the age of our race, in years, too indefinite.

We agree with him (and Dana) that man was on earth "at the close of the Glacial epoch, that he witnessed the retreat of the glaciers from Central Europe," &c. After the Glacial epoch, geologists fix three distinct epochs,—viz., the Champlain, terrace, and delta,—which have been considered of nearly equal lengths. The question then arises, have we no evidence to show the length of either of these periods?

There are facts which circumstantially give us a near approximation of the age of each, but they are nearly all based on considerations which only an expert geologist can appreciate. There are, however, in the delta period of the Mississippi, proofs which will give a very close approximation, in years, to the length of that epoch.

Various estimates have formerly been made for the time of the delta period, with varied results, Lyell and others placing it at least at 100,000 years, and others making it less. Further researches, extensively made, have confirmed Lyell's estimate. The most reliable evidence is as follows:—For a distance of about 200 miles of the delta are seen distinct forest growths of large trees, one over the other, with interspaces of sand,—showing distinct periods of the entire destruction of the forests, and, after burial, again a new generation of trees over the others. There are ten of these distinct forest growths, which have begun and ended one after the other. The outstretched, undisturbed position of the roots of the trees, as well as the other conditions of the deposits, show that they were not washed in, but grew on the spot.

Now if we can fix the time occupied by the life of these trees, we can give, at least, an approximate result. Fortu-

nately the data are clear, and can be studied by any person of ordinary intelligence. The trees in question are the bald cypress (*Taxodium*) of the Southern States, one of the largest and longest of life of the world's trees. Specimens cut down in the present age are known to be from 5000 to 7000 years old. Humboldt saw one in Mexico of extremely large size, which he estimated—from counting the rings of smaller trees of the same species to be 8000 years old.

Such are the trees found in these old, buried forests of the delta of the Mississippi. Some of the old trunks were over 25 feet in diameter. One contained over 5700 annual rings. In many instances these huge trees have grown over the stumps or fallen trunks of others equally large. Such instances occur in all, or nearly all, of the ten forest beds. Dr. Dowler, one of the best physicians and scientists of New Orleans, saw such instances in many places, and concluded that each of the ten forest growths contained, on the average, two such trees of 5000 years each, living in succession. This gives to each forest a period of 10,000 years. Ten such periods give 100,000 years, without considering the time covered by the intervals between the ending of one forest and the beginning of another. The thickness of the intervening sand shows that this interval was not, in most cases, a short one.

Such evidence would be received in any court of law as sound and satisfactory, where common sense evidence is used. We do not see how such proof is to be discarded when applied to the antiquity of our race. If the antiquity of the mastodon was in discussion no one would doubt it. Human bones have been found in the fifth forest bed, and stone implements still lower. As Rev. Mr. Templin has stated, there is satisfactory evidence that man lived in the Champlain epoch. But the terrace epoch, or the greater part of it, intervenes between the Champlain and delta epochs, thus adding to my 100,000 years. If only as much time is given to both those epochs combined as to the delta period, 200,000 years is the total result.

There are other evidences in Europe, generally clear to the geologist, which sustain this long time for the antiquity of man.—*Kansas City Review of Science.*

V. THE FORMATION OF COAL.

THE paper read by M. Frémy, the eminent Director of the Museum at the Parisian Académie des Sciences, under the title "Chemical Researches respecting the Formation of Coal," is of such great interest that we have no hesitation in making it known to our readers.

It is known that coal is produced by the decomposition of vegetable matter, which for many ages covered the surface of the earth. The learned chemist has made a series of analyses, of which he gives an account in his paper, and which have enabled him to establish the laws of this decomposition, and to explain the transformation of the tissues of the vegetable matter into coal by the loss of their organic form.

With reference to peat, the hypothesis has been put forth generally up to the present time of a possible relation between their formation and that of coal. M. Frémy has been led by the same investigations to the conclusion that the peaty fermentation is, so to speak, the first stage reached by the ligneous tissues before arriving at their complete transformation into coal.

After making these short preliminary remarks, we hasten to introduce M. Frémy in his own words.

The paper, says M. Frémy, which I read to-day on the formation of coal is the latter part of the general investigations on the vegetable tissues which I have carried on since 1850, that is to say, since my nomination to the professorship of the museum.

It is at the Jardin des Plantes that I have found everything needful for pursuing my enquiries into certain matters highly interesting and important to chemistry and vegetable physiology.

The questions which I proposed to myself were as follows:—

What is the nature of the elements of which the organs and the tissues of vegetables are formed? Is it possible to discover these elements without altering them, and to determine with some exactness their proportions? Does this chemical analysis of the tissues permit of following the development in the vegetable organisation, and of establishing a comparison between them such as science demands? Is it possible for chemistry to make known the exact com-

position of these elements, at present but imperfectly defined, such as chlorophyllus gum, the gelatinous substances of fruits, which are found in a great number of tissues, and which certainly play an important part in the vegetable organisation? Lastly, will it be possible, when all these substances are understood, to determine under what influences the tissues of these vegetables are capable of being transformed into fossil fuel, such as lignite, coal, and anthracite?

Taking this programme as the basis of my researches, I shall make a rapid survey of those investigations by which I sought to establish the nature and composition of those substances forming the skeleton or framework of vegetable matter.

The organic elements which I first examined were but little known. Their characteristic property is to produce, under the influence of fermentation or by the action of chemical reagents, a series of gummy and gelatinous substances. They may be confounded with the cell-walls themselves when they are merely subjected to microscopical examination. They often join the cells together, as is shown in the tissue forming the pith of the elder tree. I have demonstrated that the gelatinous substances of vegetables are derived from a primal insoluble substance which I have named *pectose*, and which, by successive polymerical transformations, forms at first gummy substances, then gelatinous bodies, and lastly a soluble acid, the strength of which may be compared with that of the acids found in fruits. All these transformations are produced during the growth of the vegetation.

M. Frémy then undertook the investigation of the properties and nature of the stable and fixed bodies forming the fibres, the cells, and the ducts. From these researches it results that the vegetable framework is not so simple as was commonly supposed. It is not constituted of a single substance, the cellular variously incrusted with foreign substances, but of several kinds of isomeric cellular substances. In addition to this, a very important body is also met with, which differs from the cellular in respect to its composition and properties, a body which runs abundantly in the ducts, and which M. Frémy has for this reason called *vasculose*. It is this substance which causes the hardness and density of the ligneous tissues to vary according to the proportion in which it is contained. Oak may contain 30 per cent of it, and as much as 50 per cent may be found in nutshells. The *vasculose* is placed between the walls of the fibres and

the cells, and unites them. It is dissolved by caustic alkalies.

After these internal tissues M. Frémy studied the bodies which cover and protect them, such as the cuticle. He called by the name of *cutose* the substance which forms the cuticle, and which is even found in cork. It is remarkable for its fixity, and is scarcely affected by sulphuric acid. Lastly, to complete this general study, the learned Director of the Museum examined those bodies which are most frequently met with in the tissues. Gum, for instance, is not a neutral substance, as has been commonly supposed, but a veritable salt, resulting from the combination of a genuine acid with lime. The chlorophyllus itself is not a neutral substance. It is formed of a bluish-green alkaline salt, phyllocyanate of potassa.

These preliminary researches being concluded, M. Frémy placed the top stone to the edifice by attempting the solution of the difficult and interesting problem of the formation of fossil fuel. If vegetable palæontology has made such great progress in these latter times, it may be said that the chemical part of the question has remained in absolute darkness. We know not under what influences the vegetable organisation has been destroyed to form this black bituminous mass, partly fusible, non-organic, and insoluble in dissolvents, which constitutes coal. This substance neither resembles the pyrogenous bodies produced in our laboratories nor the ligneous tissues which have formed it. By distillation it gives forth volatile products which do not resemble those given by wood. It leaves also, as a fixed body, a special substance called coke, which is very different from charcoal.

Having already introduced this question in a previous paper, M. Frémy mentioned several chemical reactions which characterised wood, peat, lignite, coal, and anthracite. Wood is not perceptibly affected by a diluted solution of potassa, whereas peat often renders to this alkali considerable quantities of ulmic acid. Xyloide lignite, or fossil wood, also contains notable proportions of ulmic acid; but it is not to be confounded either with wood or with peat, because it is transformed into yellow resin by nitric acid, and is completely soluble in hypochlorites. Compact or perfect lignite does not contain any sensible quantity of ulmic acid, but is soluble in nitric acid and hypochlorites. With respect to coal and anthracite, they are characterised by their insolubility in all the neutral solvents, acids, alkalies, and hypochlorites.

The experiments of M. Daubrée upon anthracite, and the no less interesting experiments of M. Baroullier upon coal, lead us to think that the transformation into coal is brought about by the action of heat and pressure upon the vegetable matters. In order to analyse the phenomenon, M. Frémy arranged a series of tests, in which the vegetable tissues, on the one hand, and, on the other, those substances which most frequently accompany them in the organisation, were heated to between 200° and 300° for some hours in glass tubes sealed at both ends.

In these experiments M. Frémy observed a great modification. The tissues became black, brittle, and free from water, acids, gas, and tar; but they retained their original organisation, and furnished a fixed product, offering no resemblance to coal.

The learned academician then submitted to the same test a certain number of bodies produced by organism, such as sugar, starch, gum, &c., and arrived at very different results. These bodies were transformed into substances having a certain analogy to coal: they were black, shiny, often melted, and quite insoluble in acids and alkalies.

The analysis of these bodies, which M. Frémy designates by the name of coally substances, has demonstrated the complete analogy of their composition with that of natural coal. Coal from gum gives in analysis almost the same quantities of carbon, hydrogen, and oxygen as natural coal.

From these coincidences of composition M. Frémy draws the conclusion that the elements contained in the vegetable cells—such as sugar, starch, and gum—play an important part in the production of coal.

This result was doubtless a very interesting one; but, in order to complete it, it was necessary to explain how the tissues of vegetables could lose their organic form and produce the amorphous mass called coal. Besides this, also, it was necessary that the tissues should be proved to be capable of undergoing the same coal transformation which was realised by operating upon the non-organic bodies which accompanied them.

The studies of the eminent chemist with respect to lignite and peat now proved of great assistance to him. He had seen in these combustibles the ulmic acid appear in proportion as the ligneous tissues lost their organisation. When a peat was advanced he only found insignificant remains of organic tissue, but then it contained from 50 to 60 per cent of ulmic acid. On examining the fossil wood M. Frémy found pretty thick, black, and shining layers of ulmic acid

proceeding from the transformation of *vasculose* besides the ligneous fibres, which were not yet completely disorganised.

This observation demonstrated the transformation on the spot, and in the ligneous tissue itself, of a part of the wood into ulmic acid. In this way M. Frémy was led to admit the fact which appeared to predominate in his researches, that the vegetable matter was first changed into peat before producing coal, and that in this modification the disappearance of the organic tissues was owing to a kind of peaty fermentation. To confirm this hypothesis he found it necessary to prove that the ulmic acid could, like the bodies previously experimented upon, be transformed into coal.

In consequence M. Frémy studied the transformation of three kinds of ulmic acid, and discovered that, after a calcination of 120 hours, the ulmic acid of the peat was converted into artificial coal, presenting the same composition as the coal of Blanzy.

Lastly, the mixtures of chlorophyllus, fatty bodies, and resins obtained from leaves by treating them with alcohol, when submitted to the same operation,—that is to say, heated under pressure for 150 hours,—produced a black, viscous, odorous substance, insoluble in alkalies, and presenting an evident analogy with natural bitumen.

From these facts M. Frémy draws the following conclusions:—

1. Coal is a substance which proceeds from the transformation of vegetable matter, but which no longer preserves its organic form.

2. The vegetable marks which the coal presents are produced by it, as in schist or other mineral substances, and do not prove its organisation. This fuel is a bituminous and plastic matter, on which the external features of the vegetation are moulded. When a piece of coal presents on its surface, or within its interior, marks of vegetation, it is not to be thence inferred that the adjacent parts are necessarily the result of the alteration of the tissues which were covered by the membranes whose form has been preserved.

3. The principal bodies contained in the vegetable cells, submitted to the double influence of heat and pressure, produce substances which present the properties and composition of coal.

4. The colouring, resinous, and fatty matters contained in the leaves are changed, by the action of heat and pressure, into substances which approach very nearly to natural bitumen.

5. With regard to the ligneous tissues at the base of the

cellulose and the *vasculose*, they are not transformed directly into coal. Before being so changed they pass through a process of peaty fermentation, which produces ulmic acid. It is only in the second place that this ulmic acid is transformed into coal, mingling with all the coal-forming substances produced by the contents of the cells.—*The Colliery Guardian, being translated from L'Houille.*

VI. THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

Sheffield Meeting, August, 1879.

(Continued from p. 641.)

AFTER the delivery by Prof. Johnstone Stoney of his admirable Address to Section A, an abstract of which concluded our report in the "Monthly Journal of Science" for September, the Report of the Committee—consisting of Prof. Sir William Thomson, Prof. Clerk-Maxwell, Prof. Tait, Dr. C. W. Siemens, Mr. F. J. Bramwell, and Mr. J. T. Bottomley—for commencing Secular Experiments upon the Elasticity of Wires, was read by Mr. Bottomley. The most important of the experiments conducted during the past year are those that have been made on the elastic properties of very soft iron wire. The wire used was drawn for the purpose, and is about No. 20 B.W.G., its breaking weight, tested in the ordinary way, being about 45 lbs. This wire has been suspended in lengths of about 20 ft., and broken by weights applied, the breaking being performed more or less slowly. During the breaking it was found that the wire becomes alternately more or less yielding to stress applied. Thus, from weights applied gradually, between 28 lbs. and 31 lbs. or 32 lbs., there is very little yielding and very little elongation of the wire. For equal additions of weight, between 33 lbs. and about 37 lbs., the elongation is very great. After 37 lbs. have been put on the wire seems to set stiff again, till a weight of about 40 lbs. has been applied; then there is rapid running down till 45 lbs. has been reached. The wire then becomes stiff again, and often remains so till it breaks.

The Report of the Committee for making more accurate determinations of the mechanical equivalent of heat stated that the work in progress was the protracted one of supplying a means of correcting errors in the determination of the temperature arising from the temporary changes of the fixed points of thermometers constructed of glass. An extensive series of experiments had recently been made by Prof. H. A. Rowland, of Baltimore, who, being unaware of what had been done by the Committee, had arrived at an equivalent almost identical with that determined by Mr. Joule.

The Report of the Committee for procuring Reports on the Progress of Mathematics and Physics contained two communications to the Committee, the one from Prof. Clerk-Maxwell, F.R.S., and the other from Prof. Stokes, F.R.S., giving their opinions on the questions with which the Committee has to deal.

The Twelfth Report of the Committee on Underground Temperature was read by Prof. J. D. Everett, F.R.S. One of the methods employed for taking underground temperatures is the lowering of maximum thermometers into deep bore holes filled with water. Another mode is to take observations in mines and collieries of the readings of very slow-acting thermometers. The experiments referred to include those of Dr. Stapff, made in the St. Gothard Tunnel. The mean temperature gradient for the whole length of the tunnel (about 9 miles), was found to be 1° F. for every 88 feet, but Dr. Stapff found that where the surface of the upper ground is a steep ridge the temperature gradient is less rapid than that, which is quite consistent with the hypothesis that the earth was at one time very much hotter than it is now, and that it is undergoing a process of cooling down.

The Report of the Committee on Atmospheric Electricity in Madeira was read by Dr. M. Grabham. Observing the regular winds and breezes, Dr. Grabham traced the steady rise of electricity in the early morning to a maximum at 11.30 a.m., which declines after much steadiness for two hours, at first suddenly, and then very gradually towards night.

The Report of the Committee on Luminous Meteors—read by Mr. James Glaisher, F.R.S.—dealt in detail with the accounts of conspicuous detonating fire-balls that had occurred in the United States on August 11th and December 18th, 1878, and on January 27th, 1879; in Bohemia and Saxony on January 12th, 1879; and in England on February

22nd and 24th, 1879, the real paths of all of which had to a greater or less degree of certainty and closeness been approximately ascertained. A description of the past year's aërolites was also given. The expected return of Biela's comet to its perihelion in the present year, leading a shower of shooting stars to be looked for on the 27th of November next, is to be taken advantage of to report next year on meteor showers.

The Report of the Committee on Instruments for Detecting Fire-Damp in Mines was read by Professor G. Forbes, F.R.S.E. Two new instruments have been constructed: the one of a large size, and worked by an electric battery; the other was small, portable, easily worked, and it answered all the purposes for which it was required. Both instruments were founded upon the facts that sound travels quicker in light gases than in dense ones, and that air which is contaminated with fire-damp is lighter than pure air. The velocity of sound in different qualities of air was compared by noting the lengths which must be given to a brass tube to cause it to resound to a tuning-fork. The accuracy of the instrument was such that the percentage of fire-damp could be determined with an error of considerably less than one per cent. The committee had descended the Wharncliffe Silkstone Colliery, in the neighbourhood of Sheffield (this pit has a depth of 200 yards), and were taken to a disused part of the mine where it was known there was a blower. Gas in sufficient quantities were found, and the instrument registered gas with more readiness than the Davy lamp. But the greatest quantity registered was 6 per cent, or twelve times the smallest quantity which the indicator detects. From the experiments they could assert that this instrument was capable of detecting and measuring fire damp even in small quantities.

The paper which, perhaps, attracted the most attention in Section A was that by the Rev. S. Earnshaw, M.A., on "Etherspheres as a Vera Causa of Natural Philosophy." In defining the term "ethersphere," Mr. Earnshaw said all space not filled by matter is pervaded by ether, so that every atom of matter is surrounded by ether, but this is not what is included in the word "ethersphere." If any portion of space be rendered void by ether from any cause whatever, that space has become void of the repulsive forces which were centered within it, and that, consequently, when these forces are taken away the medium outside the space will draw closer towards that space; and if the space be occupied by an atom of matter, the density of the sur-

rounding ether will be greater than before, and the ether, being in contact with the atom at its surface, will press upon it. The *excess* of ether about the vacant space above its original quantity constitutes the ethersphere; and though this gathering together of ether about the space now occupied by the atom is a consequence of the presence of the atom, it is in no way owing to its action on the ethereal medium. Mr. Earnshaw then argued that if every material atom, so must every compound system of atoms, *i.e.*, every material body, whether gaseous, liquid, or solid, have an ethersphere, which not only surrounds the whole body, but also penetrates the interstitial spaces of the body which lie between its atoms. By means of these etherspheres the author believes the phenomena of heat may be satisfactorily accounted for, on the supposition that the ethereal medium is the medium of heat as well as of light. He therefore concludes that etherspheres constitute a *vera causa* the existence of which in Nature is as certain as is that of the ethereal medium itself, about which no philosopher expresses doubt in the present day.

Mr. Gordon read a paper on "Secular Changes in the Specific Inductive Capacity of Glass." Mr. Gordon's experiments have led him to the conclusion that in the course of a year and a half an actual change had taken place in the glasses he used, which was shown by a considerable real increase in their specific inductive capacities. These experiments had some importance as regards Prof. Clerk Maxwell's electro-magnetic theory of light. In a recent lecture he (Mr. Gordon) had suggested that it was quite possible that the relation between electric induction and light exists—namely, that they are disturbances of the same ether, but that there is some unknown disturbing cause affecting the electric induction. Possibly a clue to the nature of this disturbing cause may be found in the fact that the specific inductive capacities were affected by some of the changes which chemists assert are constantly going on in glasses, but that these changes do not affect the refractive indices.

Prof. Johnstone Stoney read a paper "On the Cause of Bright Lines of Comets." Dr. Huggins and others had seen the bright lines of the carbon spectrum in the spectra of several comets. This established the fact that some compound of carbon was present in comets. Mr. Stoney suggested that the bright lines were due, not to the incandescence of the carbon compound, but to the sun's light

falling upon the compound of carbon and rendering it visible, in the same way that light renders the moon, the planets, and other opaque objects visible, the vapour of carbon being opaque in reference to the particular rays, which appear as bright lines in its spectrum.

Dr. Janssen, Member of the Institute of France, and Director of the Observatory, Meudon, read a paper "On Photographic Spectra of Short Exposure," in which he showed that in the solar spectrum the point of maximum actinic intensity was near the line G, while the point of maximum luminous intensity was near D. It occupied sensibly the same position for nearly all photographic substances and for lenses of different material. The time of exposure was graduated from five minutes to a small fraction of a second. By this means results were obtained which practically afforded a chronometric method of analysis of the solar spectrum. They had a bearing on the question of oxygen in the sun, and they led to practical improvements in the construction of photographic apparatus.

Mr. H. Courtenay Fox read a paper "On the Synchronism of the Mean Temperature and Rainfall in the Climate of London. The paper was accompanied by copious tables exhibiting the months and seasons for sixty-seven years, arranged in the order of their respective temperature and rainfall as for the Royal Observatory. The following is a short summary of the results:—1. In each of the four months from November to February, extreme cold tends to be synchronous with dryness, warmth with large rainfall. 2. In the summer months, June to August, cold tends to be accompanied by much rain, warmth by dryness. 3. To put this in popular language, rain brings warmth in winter and cold in summer; that is (if rain be the cause, which is by no means proven) it mitigates the special character of each extreme season, winter and summer. 4. Very wet years tend to be either cold or warm, whilst years of drought tend to assume an average temperature.

A paper "On Lightning Protectors for Telegraphic Apparatus" was read by Mr. W. H. Preece. For many years it was not the practice in England to protect telegraphic apparatus from the injurious effects of atmospheric electricity because the damage done was so insignificant, and because the remedy was found to be worse than the disease. But as telegraph systems increased lightning protectors became essential. Many forms were tried based on the fact that when a discharge takes place through a non-conductor, such

as dry air, at the moment of discharge the resistance along the line of discharge is practically nothing, and therefore all the charge is inducted away. Most of those tried failed. The survival of the fittest has been exemplified in the "plate" protector. In this form—one of the earliest introduced—one thick plate of brass is in connection with the earth, and another similar plate in connection with the line is placed above it, but separated from it by paper or by insulating washers. The lightning entering the wire, bursts across the paper or air-space in preference to passing through the apparatus, and thus escapes to earth. It is the practice of the Post-Office department to keep these plates apart by thin paraffined paper 0·002 inch thick. The paper contains an account of some important experiments by the author on plate-protectors, which confirm very decidedly the accuracy of the figures obtained by Drs. Warren de la Rue and Müller on the striking distance between two flat disks given by them in a paper read before the Royal Society.

Section B.

The Chemical Section (B) was presided over by Professor Dewar, F.R.S., who, in his opening Address, remarked that the time was past when the President could give a review of Chemical Work from year to year, so he took a broad view of the progress of Chemical Science. Referring to Messrs. Thomas and Gilchrist's process for the elimination of phosphorus from pig-iron, Prof. Dewar said that by far the greater portion of iron ores contain very appreciable quantities of phosphorus. Of the total phosphorus which goes into a blast-furnace, whether with the ore or with the limestone, nine-tenths are contained in the resulting pig-iron. The Bessemer process did not eliminate phosphorus from pig-iron treated by it, and extremely small proportions of phosphorus render steel "cold short," so that the process had hitherto only been applicable to the rarer and costlier kind of pig-iron produced from exceptionally pure ore. Even thus restricted the Bessemer process had produced results of incalculable importance, and the imagination could scarcely grasp the extent of the further development it must receive and the importance of the further benefits which must now flow from it.

We have not sufficient space to refer to the many valuable papers brought before this Section. We must, however, mention a note by Mr. J. Norman Lockyer, "On the Sup-

posed Compound Nature of the Elements." Continuing his researches on this subject, he found that when carefully distilled metallic sodium is condensed in a capillary tube, placed in a retort, and heated in a Sprengel vacuum, it gives off twenty times its volume of hydrogen. Phosphorus, carefully dried, gives off 70 volumes of gas, chiefly hydrogen. A specimen of magnesium, carefully purified by Messrs. Johnson and Matthey, was magnificent in its colourings; it gave first hydrogen, then the D line, then the green lines of magnesium (*b*), then the blue line, and then, as the temperature was increased, various mixtures of all of them, the D line being always the most brilliant. In this experiment only two volumes of hydrogen were collected. From gallium and arsenic no gas is given off. From sulphur and some of its compounds sulphurous anhydride was always obtained. From indium, hydrogen was given off before heating; while from lithium no less than 100 volumes of hydrogen were given off.

Dr. Gilbert, F.R.S., read a paper "On some Points in connection with Agricultural Chemistry," in which he stated that Mr. Lawes, at Rothamsted, and himself, had now grown wheat for 36 years in succession on the same land, barley for 28 years in succession, oats for 10 years, root crops for more than 30 years, beans for more than 30 years, and they had experimented with mixed herbage on grass land for 24 years. They found only minor distinctions in the manurial requirements of different plants of the same natural family, but very great distinctions in the requirements of plants of different natural families. The gramineous crops are very low in the percentage of nitrogen, and yield but a very small quantity per acre. Yet nitrogenous manures are very effective when applied to such crops. Leguminous crops, on the other hand, are very high in the percentage of nitrogen, and yield a very large amount of it per acre. Yet nitrogenous manures are of little avail to these plants, and potash manure is especially effective. The differences in manure requirements of plants of all natural families were also pointed out. Much more complicated, however, was the problem when experiments were made upon mixed herbage of grass land, where they might have fifty or more species growing in association, representing perhaps twenty natural families. One point of especial interest was the difference in the amount of nitrogen yielded by the plants of the different natural families. It was assumed by some that some plants assimilated the free nitrogen of the atmosphere; but so far as existing evi-

dence went the author considers it much more probable that the soil is the source of the combined nitrogen. Experiments show that by the growth of wheat or barley for many years in succession on the same land without nitrogenous manure, the annual yield of nitrogen in the crop gradually diminishes. There was also a diminution in the percentage of nitrogen in the soil. In the case of the root crops the diminution in the percentage of nitrogen in the soils was also greater. With beans there was also a diminution in the yield of nitrogen in the crop, but still much more was yielded, even at the conclusion, than with either wheat or barley. In these cases there was not found a reduction of nitrogen in the soil. In the case of mixed herbage experiments, very much more nitrogen was yielded by the application of potash manure, and here there was a great reduction in the percentage of nitrogen in the soil. The percentage of nitrogen in the soil was also very largely reduced in the case of clover grown for many years in garden soil. Part of this reduction might be due to other causes, but the indication was that the Leguminosæ had derived their nitrogen from the soil. Admitting that the sources of the whole of the nitrogen of vegetation were not conclusively made out, he nevertheless considered that the existing evidence was against the idea of the assimilation of free nitrogen by plants, and in favour of an opinion that free nitrogen was mainly, if not entirely, derived from the soil.

Section C.

The President of the Geological Section (C), Professor P. Martin Duncan, in his Address, said that of all the geological formations the carboniferous gave the earliest clear and definite idea of a land surface on the earth, or rather of the existence of many lands. In reflecting upon the history of the carboniferous deposits, in relation to the subsequent great changes in the physical geography of the earth, the idea that geological histories repeated themselves did not obtain that importance with which it is credited in relation to human events. It was true that there were extensive triassic, oolitic, wealden, neocomian, and tertiary lands, whose vegetation had been metamorphosed into a kind of coal; but the wonderful depth, and the extraordinary vertical repetition of organic and inorganic deposits of the carboniferous formation, and the remarkable crust movements which enabled them to accumulate, were without subsequent examples.

The Sixth Report on the Conductivities of Coral Rocks, prepared by Prof. A. S. Herschell and Prof. G. A. Lebour, was read. The research and correspondence necessary to complete a historical sketch of the attempts hitherto made to determine experimentally the thermal conductivities of the terrestrial rocks most widely distributed, which the Committee had proposed to draw up during the past year, were not so far advanced at present as to allow them to be comprised in this year's report. The Committee hopes, by continuing its inquiries for another year, with the addition to its number of Prof. W. E. Ayrton and Mr. J. Perry, of the Imperial College of Engineering in Japan, to carry out the object of their undertaking, so as to exhibit our existing knowledge of the date of thermal conductivity of those widespread kinds of rock which constitute the external materials of the globe.

The Fifteenth Report of the Committee for Exploring Kent's Cavern, Devonshire, was read by Mr. W. Pengelly, F.R.S. He observed that this was probably the last report he should present on the subject, as the exploration work was fast drawing to a close. Work during the past year has been carried on in the "High Chamber" and its branches. This "High Chamber" contains only breccia, the oldest mechanical deposit in the cavern, and the crystalline stalagmite which overlies it. Bones of bears and implements have been found in the breccia here, and also in that of the southern branch, called the "Swallow Gallery."

Section D.

The Biological Section was presided over by Professor St. George Mivart, F.R.S., who, in his Presidential Address. referred to the life and labours of Buffon, noticing his speculations concerning animal variation; his belief in the direct effect of the surrounding circumstances on organisms; and also his belief that new species have arisen by degradation. We may, Prof. Mivart thought, accept as true two propositions:—(1.) Animals may change in various ways, and amongst them, by degradation. (2.) Changes in the environment with isolation, induce and favour changes in form. He urged that inquiries should be pursued in two directions simultaneously. (A.) There might be undertaken one set of inquiries to investigate the effects on different species of the same variation of environment. (B.) Other inquiries might be undertaken with a view to ascertaining

the effects of different changes of environment on one and the same species. The President then directed attention to the resemblances and differences which exist between the mind of man and the higher physical faculties of animals.

In the Department of Anatomy and Physiology the President was Dr. Pye-Smith, F.R.S., whose address attracted great attention. Biology, he remarked, is the science of the structure, the functions, the distribution, and the succession in time of all living beings. If the proper study of mankind be man, he has learnt late in the inquiry that he can only understand himself by recognising that he is but one in the vast network of organic creation; that intelligible human anatomy must be based upon comparative anatomy; that human physiology can only be approached as a branch of general physiology, and that even the humblest mould or sea-weed may furnish help to explain the most important problems of human existence. Speaking of the relation of physiology to the national health Dr. Pye-Smith said that if the art of keeping a community in health is but the application of plain physiological laws, it is no less true that the art of restoring the health, curative as distinct from preventive medicine, rests upon the same basis. We now know that disease is, as the name implies, a purely subjective conception. The disease of a host is the health of the parasite, and we cure a human sufferer by poisoning the animals or plants which interfere with his comfort. The same changes which in the old man are the natural steps of decay, the absence of which after a certain age would be truly pathological, are the cause of acute disease in the young. Pathology has no laws distinct from those of physiology. It clearly follows that all "systems of medicine" are in their very nature condemned. All that the art of medicine can do is to apply a knowledge of natural laws, of mechanics, and of hydrostatics, of botany and zoology, of chemistry and electricity, of the behaviour of living cells and organs when subjected to the influence of heat and of cold, of acids and alkalies, of alcohols and ethers, of narcotics and stimulants, so as to modify certain deviations from ordinary structure and function which are productive of pain, or discomfort, or death. Rational medicine, or keeping right and setting right the human body, must therefore rest upon a knowledge of its structure and its actions, just as a steam-engine or a watch cannot be mended upon general principles, but only by one who is familiar with their construction and working, and who can detect the source of their irregularity. With regard to the

endowment of research in biology, Dr. Pye-Smith confessed that he should be sorry to see it undertaken by Government funds. This country is not so poor, nor our countrymen so wanting in public spirit, that we need appeal to the national purse to supply every ascertained want. Great as is the national importance of science, the nation was more important still; and even if that were the alternative he would rather that we should indefinitely continue dependent on Germany for our knowledge than give up the local energy, the unofficial zeal which has made England what she is. Coming to Vivisection Dr. Pye-Smith referred to the reasons which animate much of the opposition to Vivisection, many of which we have discussed in the "Monthly Journal of Science." With regard to the recent legislation he said that a system of licenses and certificates, revocable at the will of a Minister who may, by the accidents of party, be at any time amenable to anti-scientific influences, adds serious difficulties to those already in the way of experiments. As an illustration, he asked his audience to suppose that certain persons opposed on various grounds to learning, and especially hostile to Greek, had attacked the study of Plato. They would point out the danger of modern ladies becoming as well read in his writings as was Lady Jane Grey. They would show that the laxity of modern manners was coincident with the popularity of the "Symposium," and that the notorious increase of infanticide was the result of the teaching of the "Republic." Associations for the total suppression of Plato would be formed, with hired advocates, and anonymous letters, and "leaflets," spreading a knowledge of his most objectionable passages. Scholars would be threatened with eternal punishment, and schoolmasters with the withdrawal of their pupils. Then a royal commission would be appointed—a great Latin scholar, a Whig and a Tory statesman (who, having taken a B.Sc. degree at Oxford would be impartially ignorant of Greek) the most intelligent despiser of Plato who could be found, the master of a grammar school on the modern side, and (perhaps the most efficient of all) a lawyer, who knew nothing about Greek but hated cant. This commission would take evidence that the Platonic writings were not all immoral, that they had been quoted with approval by Fathers of the Church, that they were of great importance to literature and philosophy, and even to the elucidation of the Sacred Writings. It would also be proved that the Platonic Dialogues were far less immoral than multitudes of other widely circulated books, or than a French novel

which one of the royal commissioners happened to be reading, and, lastly, that the morals of Greek scholars, and of clergymen who had read Plato at college, were not obviously degraded below those of other people. On the other hand, witnesses would depose that a knowledge of Plato was of no consequence to a student of philosophy; that if it were, the text was in so corrupt a condition that no two scholars agreed as to a single chapter, and that, after all, philosophy was of no practical use, least of all to clergymen. Others would affirm that though they had never read a line of him, they knew that his style was as vicious as his sentiments; and perhaps some cross-grained scholar might be found who, having once edited a play of Euripides, would declare that all studies in Greek literature ought to be restricted to the tragedians, and that for his part he had never opened any other authors, and had never felt the want of them. At last the commission would report that there was no question of the value of the works of Plato, that it would be mischievous and impracticable to prohibit their study, and that there was no evidence that schoolmasters habitually chose the least edifying passages as lessons for boys. Then what is called a compromise would be made. It would be enacted that Plato might be read, but only in colleges annually licensed for that purpose; that every one wishing to read must have a general certificate signed by certain professors, and setting forth his object, also to be renewed every year; and that special certificates might be severally obtained for reading certain excepted dialogues, for copying from them, for publishing them, or, in rare cases, for translating them. However reasonably such a system might be administered, who can doubt the result would be a diminution of the number of scholars, and a check to the progress of learning? Now this is what legislation has done for physiological experiments. The Act (39 and 40 Victoria) was hastily drawn and hurriedly discussed; for noble lords and honourable gentlemen who had been taught from childhood to vivisect for unscientific purposes were eager to hurry off to their own merry vivisections, for which they were ready provided with licence and certificates. And it works as might be expected. Some shrink from seeing their names figure in disreputable newspapers, and receiving more or less savagely abusive anonymous letters. Others have no laboratories, and find difficulty in licensing their houses. Others are refused the certificates they require. In one case two thoroughly qualified men were anxious to carry out an important investigation on the treatment of snake-bites. They

procured venomous snakes from a distance, and applied for the special certificates necessary. Considerable delay ensued; various objections were raised, and set at rest; and at last all the certificates were obtained; but meantime the snakes had died."

In the Department of Botany Sir John Lubbock read a paper on "Seeds." He directed attention to the difference in seeds, some being large, some small, some covered with hooks, some provided with hairs, some smooth, some sticky, &c. Many seeds required protection from birds and insects, hence the shells or husks of the beech, Spanish chestnut, horse chestnut, walnut, &c. In some cases, as in the common herb, the calyx closed over the seeds when the flower faded, and opened when the seeds were ripe. In other cases the flower stalk changed its position. The modes of dispersion by means of which seeds secured a sort of natural rotation of crops, and were also in other cases enabled to rectify their frontiers, were also described. Some plants threw their seeds. Among the higher plants the seeds were transported by the wind. Many seeds were provided with a wing which caught the wind, and these and kindred aids in dispersion were as various as the plants themselves. The dispersion was often effected by the agency of animals. In some cases the action of animals was involuntary, and these might be divided into two classes, those in which the seeds adhered to animals by hooks and those in which this was effected by sticky glands. The seeds of a South African plant, provided with hooks more than an inch long, were said sometimes even to destroy lions. They rolled about on the sandy plains, and if a seed attached itself to the skin the wretched animal tried to tear it off, and getting it into his mouth was fatally injured. Sir John, in conclusion, called attention to mimicking seeds, such as the scorpiurus, the pods of which did not open, but looked so exactly like worms that birds were induced to peck at them, and thus the seeds were freed.

A paper on the effects of the frosts of 1860-61 and 1878-79 on vegetation was read by Mr. E. J. Lowe, F.R.S., from which it appeared that the greatest cold of 1860 exceeded that of last winter by 10 degrees, being 6 degrees below zero in 1860, whilst it was 4 degrees above zero during the late frost. Instead of the cold killing the slugs and various pests of plants they were never known to be so numerous. Many hardy plants in pots were killed when they escaped if planted in the ground.

Section F.

We must not omit a notice of two papers brought before the section of Economic Science and Statistics, the one by Dr. J. H. Gladstone "On Elementary National Science in Board Schools;" the other by Prof. Leone Levi "On the Scientific Societies in Relation to the Advancement of Science in the United Kingdom."

Dr. Gladstone pointed out that in elementary schools a knowledge of the facts of nature is generally given in two very different ways. In the infant department there usually lingers some remnants of that instruction by object lessons which was considered a valuable part of education before the Revised Code of 1861. In the higher standards of the boys' and girls' departments certain sciences may be taught as "specific subjects," and receive encouragement by a Government grant. At the present time out of 1074 male and 1790 female teachers, 888 males and 442 females hold advanced science certificates, varying in number from 1 to 23. Advanced object lessons, generally on natural history, are taught in many of the boys' and girls' departments, and there is little doubt that they will soon become much more general and systematic. Out of 248 boys', 218 girls', and 46 mixed schools, more than half include in their course of instruction scientific specific subjects. The cost of books and apparatus for the instruction in natural knowledge during the past twelvemonth was £834. This amount is rather less than one penny per child per annum.

Mr. J. F. Moss advocated the establishment of centres, at which this class of work could be done by selected teachers and under far more favourable conditions than at present existed. Branches of science more immediately bearing upon the industries of each district should have special prominence so as to aid in the training of intelligent artisans, foremen, and managers instead of depending so largely for the supply of educated men from other countries where greater attention had been given to technical education with such important results.

Prof. Silvanus Thompson advocated apprenticeship schools, but if such schools were established in England it should be by local rather than Imperial effort, for they succeeded better when they were not fettered by Imperial legislation.

The President (Mr. Mundella) believed that science teaching tended to redeem school life from its drudgery and monotony. In the science schools abroad the interest manifested by the children in a proper object lesson and the

facility with which they acquired knowledge had very much struck him.

In his Address on Scientific Societies, Prof. Leone Levi said that in the seventeenth century there were only two scientific societies in this country, but at the present time the calendar exhibited an amount of activity quite unknown at former periods. In 1878 the number of members for the Royal Society was 549; for the Royal Society of Edinburgh, 429; and for the Royal Irish Academy, 328. The societies devoted to physical and mathematical sciences had, in 1878, 5406 members; the natural history sciences, 16,534; the archæological and geographical societies, 5038; and the societies whose object is the study of the applied sciences, 21,947. The amount voted by the State in 1878 for education, science, and art amounted to £4,153,000. If, however, they eliminated from the total vote the amount expended for elementary education, the proportion left for science and art was considerably diminished, amounting only to £529,000. Government aid was principally given to physical and natural science, leaving a wide range of scientific exploration altogether unassisted. It was not to be desired that Science should be subsidised by the State, but the claim of Science had been fully recognised.

The Chairman (Mr. Shaw Lefevre, M.P.) agreed with the speakers that the multiplication of members of scientific societies did not necessarily indicate the growth of excellence in Science and an increase in the number of scientific men. They really required some standard, for there was no doubt that the members of some learned societies placing so many letters after their names was just an indication that they could subscribe a certain number of guineas in the year. The Royal Society had taken a step in the right direction in limiting the number of its Fellows. He always thought the letters "F.R.S." a much greater distinction than "M.P.," for it was impossible that that honour could be acquired except by the possession of great and solid attainments.

Section G.

The President of the Mechanical Science Section (Mr. J. Robinson) chose for the subject of his Address the "Development of the Use of Steel during the last Forty Years," considered in its Mechanical and Economic Aspects." Referring to the enormous reduction of price, and consequent more frequent and more economic application of steel, the President said that, following the initiation of Krupp, our

English engineers and men of science set themselves to work to discover and apply new processes for the production and manufacture of this most wonderful metal; and in the whole history of metallurgy, from the time of Tubal Cain downwards, there has been no such progress in invention and manufacture as has been realised by the aid of such men as Mushet, Krupp, Bessemer, Siemens, Whitworth, Martin, Vickers, Bell, Bauschinger, Styffe, and many others within the last forty years.

An important paper was read by Captain Bedford Pim, "On the proposed Canal across the Isthmus of Panama." He estimated that the canal would not cost more than ten millions.

A paper "On Leon Francq's Fireless Locomotive" was read by M. C. Bergeron. The idea of such a locomotive was originated at the time of the horse plague in New Orleans, in 1872. After the Franco-German war M. Francq, who was connected with the Paris tramways, gave his attention to discovering a motive power for his tram-cars. The object he had in view was in obtaining such heat from water as would supply the motive power he needed. The engine in question was the result of his investigations. It had a large cylindrical reservoir, surmounted by a steel dome, two cylinders acting with piston rods, and a crank carrying two driving wheels, which were connected with other two wheels. The reservoir holds more than 700 gallons of water, heated to such an extent as to produce a pressure of 224 lbs. to the square inch. It was claimed for the new engines that they were very economical in every respect. It was pointed out that the engine would be especially useful on the Metropolitan lines, as it neither gave off smoke nor deleterious gases. In a few weeks an engine of this character will be used on the tramway at Leeds and another at Liverpool Docks.

At the concluding General Meeting of the Association it was announced that the Meeting in 1880 will be held at Swansea, the President-Elect being Prof. Ramsay, LL.D., F.R.S.

NOTICES OF BOOKS.

A Manual of the Geology of India. Chiefly compiled from the Observations of the Geological Survey. By H. B. Medlicott and W. T. Blanford. Calcutta: Geological Survey Office. London: Trübner and Co.

We have had, from time to time, the pleasure of drawing the attention of our readers to the important results worked out by the Geological Survey of India. The memoirs and reports of the Survey have become too numerous and bulky for general consultation. Much information on the Geology of India is scattered in various learned journals, both Indian and European. Hence a digest or compendium, showing at least the more important facts observed and the chief conclusions arrived at, has become imperatively requisite, and we are glad to learn that the Government has seen this necessity, and has directed the present Manual to be drawn up.

The first volume is devoted to peninsular India, whilst the second treats of the extra-peninsular portions, such as Sind, the Punjab, the Himalayan and Sub-Himalayan regions, and British Burma. Concerning this extra-peninsular area it is remarked that it is "geologically an intrinsic portion of the Asiatic continent, whilst peninsular India is not."

The authors find ample evidence that India was affected by the cold of the Glacial epoch. The poverty of the living fauna as compared with the fossil fauna of the Siwaliks, as Mr. Wallace happily suggests, is best explained by a secular decrease of temperature. The eleven extinct elephants and mastodons are now represented by a solitary living form. Against fifty known fossil species of ungulates the same area affords only eighteen recent forms. The Tálchir formation displays the same kind of evidence by which the existence of a Glacial epoch is recognised in more northern regions.

As regards the former distribution of land and water, the authors conclude that in Eocene times peninsular India was part of a tract of land, perhaps even of a great continent connected with Africa. To the east and north-east was a sea, where now rise the Assam hills, whilst on the north-west another sea covered great part, if not the whole, of Persia, Baluchistan, the Indus plain, and part of the plain of the Upper Ganges. The recent fauna, they believe, speaks in favour of the connection of Southern India with the Malay Islands and Africa in the early Tertiary times.

The authors do not entirely agree with the system of anima

geography propounded by Mr. Wallace. On comparing the mammalian fauna of the Oriental region with those of the three neighbouring regions, they consider that the strongest affinities are with the most distant of the three—the Ethiopian. This, they hold, points to the existence of an older fauna once common to Africa and India, though now partly replaced in either country by newer types. It has been supposed that Ceylon, with the southern portion of the Indian peninsula, may have been united with the Malay countries later than with Africa. As far, however, as the sea-bottom between Ceylon and the Malay Islands is known, there is nothing to prove a recent extension of land in this direction. The affinities of the land-shells of India are rather with the Australian than with the African fauna. As these molluscs are supposed to be of very high antiquity, the resemblance may be due to a communication existing in the Mesozoic times.

The existence of a former continent, Lemuria, stretching from Madagascar to the Malay Islands, and connected at times with Africa, and at times again with Asia, still remains a speculative question. But that the interval between Africa and India was once bridged over, so as to admit of the easy interchange of mammalian species, scarcely admits of doubt.

As regards its soils, the authors state that India may be very roughly divided into the extra-tropical wheat-region; the damper portion of tropical India—the rice, sugar, &c., country; and the drier tropical parts—the so-called black-soil country, suitable for the cultivation of cotton. The wild floræ of these three regions are respectively as distinct as are the cultivated crops.

Pre-historic implements, bearing marks of human or anthropoid industry, have been found in India to a considerable extent. Chipped palæolithic weapons were first found near Madras by Messrs. Foote, King, and Oldham, and have been subsequently met with in Orissa, Bengal, and Assam. Knives made from agate, flint, or chert are possibly of more recent origin than the quartzite implements. Similar flakes are still in use among the natives of the Andamans. Neolithic stone implements—so-called "Celts"—with surfaces smoothed by grinding, have been noticed at Kirwi, Chutia Nagpur, and Kurg. A single bronze axe has been discovered near Jabalpur. Copper weapons are more numerous, but still scarce. Iron implements are abundant, and the authors suggest that the art of working this metal may have been discovered earlier in India than in more western regions. They consider that closer and more extended research in India will doubtless bring to light important evidence on the earlier career of the human species.

The work is illustrated with a judicious assortment of figures of Indian fossils of different epochs, and is further provided with an Appendix in the shape of a very large geological map, which forms a companion volume.

CORRESPONDENCE.

WEATHER-INDICATIONS.

To the Editor of the Monthly Journal of Science.

SIR,—Have any of your meteorological correspondents noticed a fact with which I have often been struck,—that is, that in a season of confirmed character the ordinary weather-indications become of no value? Thus in 1868 I often observed that lowering clouds, a red sunrise, the low flight of swallows, eddies of dust, &c., were not followed by rain. Conversely in the present season, a rising barometer, red sunsets, very lofty flights of swallows, and other indications of fair weather, are succeeded by rain.—I am, &c.,

CLOUD-GAZER.

ANTI-VIVISECTIONIST INCONSISTENCY.

To the Editor of the Monthly Journal of Science.

SIR,—In a recent magazine article a distinguished writer, after describing with great zest a day's trout-fishing which he enjoyed at Cheneys, enters upon the defence of "sport" in general, which he defines as killing for the sake of killing. He ventures on the unwarrantable statement that save "the dogs and the cats which have learnt from him," man is the only animal which indulges in such gratuitous slaughter. Waiving, however, any present discussion on this point, I cannot help remarking that to indulge in and to justify "sport" come with a very bad grace from one who, like the writer in question, is an avowed opponent of vivisection.

If the common infliction of pain and death upon animals for mere amusement, or for the exercise and display of skill, is to be tolerated without rebuke either from law or from public opinion, how can a much rarer infliction of pain for a high and important purpose be branded as a horrible crime?—I am, &c.,

J. W. SLATER.

NOTES.

Biology.

M. E. Renon predicts a series of bad seasons until 1883, when the summer is to be warm. The winter of 1881-82 will be exceptionally severe. He assumes a period of 41 years, the beginning and end of which are characterised by bad weather. Referring to the fact that in the past July, as in July, 1758 and 1816, the temperature in Western Europe was exceptionally low, though accompanied by south and south-west winds, he supposes that the African current, in place of taking its usual course over Spain, France, &c., has been deflected to the east, thus accounting for the great heats experienced in Italy, Hungary, Bulgaria, &c.

In a paper on the "Production of Electricity by the Rays" M. Ch. Robin states that, as early as 1865, he demonstrated that the electric apparatus in the tail of the Ray acts in the same manner as those of the Torpedo and the Gymnotus, the differences between them being merely of a secondary nature. Quite recently he has verified anew the exactitude of his former observations.

"La Correspondance Scientifique" gives an interesting account of the museum founded at Cette by M. J. B. Doumet, a young French officer who, in 1815, was dismissed from active service on account of his suspected attachment to the Empire. It is exceedingly rich in the mollusks, crustaceans, fishes, and reptiles of the Mediterranean and of the adjacent countries. The collection of exotic Lepidoptera is also very fine. One of the greatest curiosities is the original herbarium of Michel Adanson, the celebrated botanist, the maternal grandfather of Doumet.

P. H. Reinsch has observed the occurrence of the mycelia of fungi in a hen's egg ("Botanische Zeitung," 1879, No. 3, pp. 37, 38).

M. A. Chaveau, in the course of experiments described in the "Comptes Rendus," observes that certain Algerian sheep were perfectly proof against the poison of carbuncle, even on repeated inoculation—a fact which raises a number of most important questions.

Professor K. Th. Liebe, in the "Transactions of the Imperial Academy of Sciences of Vienna," contends that during the second diluvial period the hills of southern Bohemia and Moravia were the starting-point from which the virgin forests invaded the great diluvial steppe of Central Europe to the north of the Alpine chain.

M. B. Schnetzler communicates to the Academy of Sciences certain observations on *Arum crinitum* and its relations to insects. Its carrion-like odour entices numbers of flies, such as *Musca Cæsar*, which lay their eggs at the bottom of the spathe where the resulting larvæ necessarily perish. Common flies and even Acarides are often found imprisoned among the hairs. Some flies, however, less eager to lay their eggs, are attracted by the glandulous hairs upon the spadix, which lead them, like the steps of a ladder, to the stamens. There, on alighting upon the anthers, they cause the pollen to be emitted, and fly away to deposit their eggs in another spathe, at the bottom of which they deposit upon the stigmata the pollen brought from the former flower. The dead flies, though upon a moist surface, appear dried up. It appears that the hairs which overspread the inner surface of the spathe secrete an acid which, like that exuding from the hairs of *Drosera*, contributes to the transformation of the nitrogenised parts of the insects into matter absorbable by the spathe. Hence the author, without denying that insects contribute to the fecundation of this flower, contends that they contribute to its nutriment, and holds that it was rightly named *Arum muscivorum* by the younger Linnæus.

According to Ernesto da Canto, the smoke of burning straw or brush-wood has been found very beneficial to a variety of plants, but especially to the pine-apple. The observations were made in the hot-houses used in the Azores for forwarding pine-apples in the cold season.

In the "Rivista Orticale" hemp-plants are recommended to be cultivated in vineyards, orchards, &c., for the banishment or destruction of noxious insects. The absence of insects in hemp-fields is said to be a well-known fact.

Worms have been observed in fresh hens' eggs at New York. The species was not determined, but it may probably be *Distoma ovatum*, which lives parasitically in the cloaca of poultry.

In a paper communicated to the Academy of Sciences M. Richet shows that muscles in a state of contraction are more excitable than when in a state of repose. The relaxation of a muscle is not abrupt, but gradual, and the true form of the muscular shock is masked by the weights which extend the muscle. For muscles extended by a weight there is a period of *latent contraction*, during which the muscle is most excitable.

M. Poincaré has ascertained that guinea-pigs are affected by the vapour of nitrobenzol much more seriously than is man. Workmen exposed to these fumes in the manufacture of aniline rarely experience more than a transient loss of consciousness, which is at once removed on exposure to the fresh air. All the guinea-pigs experimented upon perished. On examination the liver, kidneys, nervous centres, and lungs were all found strongly congested. The chief symptom observed during life was a difficulty of breathing.

M. Léon Fournol, in the "Journal d'Hygiène," gives an interesting summary of our present knowledge concerning poisonous fishes, which appear to be a source of grave danger. We may trace here four distinct cases. There are fishes perfectly harmless at some seasons of the year, but poisonous at others. This has been observed in Japan with the common salmon, the bonito, and the albicore. The symptoms generally resemble those caused by the ingestion of corrupted meat, and though alarming are rarely fatal. Other fishes, such as *Lethrinus namboo*, are wholesome when young, but become poisonous when they reach a certain growth. Other aquatic animals—the conger, the pike, the barbel, the prawn, and the mussel—are occasionally and capriciously poisonous. In one instance a number of persons who had partaken of the spawn of a large barbel experienced very severe symptoms of poisoning, whilst one of the party who had not eaten any of the spawn escaped. The liver and the head in several species of fish inhabiting different parts of the world are found exceptionally dangerous. The occasionally poisonous action of mussels, oysters, &c., is ascribed by eminent authorities to their having eaten the eggs of the star-fish, which are occasionally found in these mollusks on dissection, and which, when handled, produce violent cutaneous irritation. Other fishes appear to be poisonous at all times and under all circumstances. Prudence dictates that the roe, liver, &c., of all unknown fishes should be carefully avoided, and it is very doubtful whether aquatic species of animals too small to admit of the removal of the alimentary canal, with its possible contents, should be eaten at all. The entire question offers a splendid field for research, both biological and chemical.

M. J. Künckel has published in the "Comptes Rendus" the results of an extended series of researches on the nervous system of the Diptera. He recognises in some cases an absolute centralisation, or an extreme dispersion of the nervous centres, with the most varied intermediate arrangements, but each family has its nervous system constructed upon a peculiar and invariable plan. The number of nervous centres varies, however, gradually from one family to another.

M. E. Brandt has laid before the Academy of Sciences certain interesting results concerning the nervous system of insects. He finds that in the genera Rhizotrogus, Stylops, and Hydrometra the subœsophagian ganglion is not separated from the following ganglia, as has been supposed to be the case in all insects. Hence this character can no longer serve to distinguish the nervous system of insects from that of the other Arthropoda. The pedunculated bodies of Dujardin, or the cerebral circumvolutions, are not only met with in some insects, but in all. In some insects a difference in the development of these convolutions is found, even among different individuals of the same

species. Wagner's assertion, however, that in the male bee these convolutions are entirely wanting, is inexact. They are present in all male insects, though in the social species in a much lower degree. The development of that portion of the brain named the hemispheres is proportional to the grade of intelligence, though that of the entire brain is not. In the Lepidoptera, Coleoptera, Hymenoptera, and Neuroptera the first thoracic ganglion is simple, and the second compound. In others (such as several dipterous genera), both the first and second thoracic ganglia are compound.

According to M. Arloing, the formiate of soda lowers the temperature of the animal system. It neither affects the heart nor the kidneys as profoundly as does the salicylate.

MM. Brissaud and Richet, writing in the "Comptes Rendus," point out that there is a very intimate connection between the normal muscular tone, catalepsy, cramp, myo-reflex contraction, and the contraction of hemiplegia, and that forms of transition between these states will, doubtless, be traced.

From experiments upon *Scyllium canicula*, M. Cadiat concludes that digitalin, given in a toxic dose, is a heart-poison, acting directly upon that organ and producing a tetanisation of the ventricle and a diastole of the auricle. It has no action upon the nervous centres, the peripheric nerves, or the muscles.

According to M. de Brévans, flights of swallows are sometimes seen going northwards as late as October, returning again to the south when leaving Europe. The author—as quoted in "Les Mondes"—remarks that this year the swallows have returned later than usual. This does not agree with observations made in England.

M. E. Heckel has observed a well-marked case of trichinosis in a young hippopotamus which died in the Zoological Gardens at Marseilles. He asks if the pachydermata are especially liable to a spontaneous development of this terrible parasite?

M. Dareste, having placed eggs in warm water of a temperature proper for incubation, found that all of them presented marks of incipient development, though in every case the embryo had perished. In one case only the structure had escaped decomposition, and it was a monstrosity of the class which the author has described as omphalocephalous. The heart, clearly distinguishable, was placed above the head.

Dr. A. W. Lyte, in the "Medical Brief," recommends the oil of sassafras as an effectual antidote for the bite of the copper-head snake, and as destructive to all insect life.

The application of osmic acid to microscopical purposes forms the subject of a paper read before the Royal Microscopical Society on the 12th of March by T. J. Parker, B.Sc. It is valuable principally on account of its property of killing and

hardening protoplasmic structures with the minimum of shrinkage, and also staining fat of an intense black colour. The former property renders it of great value in embryology and in the study of infusoriæ and delicate animal tissues: the latter gives it its pre-eminence in bringing out the ramifications of the finer medullated nerves, and the structure of the adipose tissue. Some recently-hatched glass-crab (Phyllosoma) were immersed for ten minutes in a 1 per cent solution of osmic acid, and subsequently treated with alcohol of gradually-increasing strength, commencing with 50 per cent, and ending with absolute. The central nervous mass was stained jet black; the muscles, glands, &c., assumed a greyish brown, the striæ of the muscular fibres becoming remarkably distinct. It has been used with great success for the preparation of delicate vegetable tissues; the manipulation is similar, after staining and treatment with alcohol; soaking in oil of cloves follows; the sections are cut by imbedding in cocoa butter, and mounted in balsam. A mixture of osmic and chromic acids (chromic acid, 0·25 per cent, 9 parts; osmic acid, 1 per cent, 1 part) answers, in some respects, better even than osmic alone for vegetable preparations.

In the same journal (vol. II. p. 354) is a paper by George Hoggan, M.B., and Frances Elizabeth Hoggan, M.D., "On the Development and Retrogression of the Fat Cell." The mode of preparation of the specimens is minutely described, and the manipulation and effect of the various staining and other reagents given in detail.

The employment of osmic acid and other stains is opening a new field for the histologist. The following process is used by Dr. Richard Altmann, of Giessen, for the investigation of certain animal tissues under the microscope:—The tissue is either impregnated by soaking, or else its vessels are injected with olive or castor oil, and then placed in osmic acid until the oil is hardened and blackened; finally it is transferred to a solution of potassium or sodium hypochlorite ("Eau de Javelle"), which completely destroys the tissue, the fatty material being left, and retaining the form of the vessels or spaces into which it was injected. The solution of osmic acid is of 1 per cent strength. The process has been successfully employed for the investigation of medullated nerve, striped muscle, epithelium, cornea, choroid, and retina. Full details will be found in the "Archiv fur Mikroskopishe Anatomie." vol. xvi. (1879), p. 471; a translation in the "Journal of the Royal Microscopical Society" for August. The Royal Microscopical Society are doing good service by the carefully-selected translations of foreign papers on biological subjects.

Chemistry and Technology.

It would seem that restrictions upon the Chemical Arts, to whatever length they may be carried, must fail to prevent the

injuries to which farmers and landowners complain, for in a paper published in "Die Chemische Industrie" on the "Injury to Vegetation by Acid Gases," Herr R. Hasenclever admits that many causes, in addition to the fumes of chemical works, have had a deleterious action upon trees. He points out that the use of coal as fuel, whether in private houses or in mechanical manufactures, &c., has exerted a very devastating action upon vegetation. The memoir is accompanied by a coloured engraving of the leaves of various trees as affected by acid vapours. German observations confirm the view entertained in this country, that the plane-tree is distinguished by its power of resisting acids.

An exhaustive research on the action of ozone upon the colouring matters of plants has been conducted by Prof. A. R. Leeds. The colouring matters of both leaves and flowers of the species experimented upon were partly or wholly destroyed by ozone; but Prof. Leeds found that a considerable percentage of ozone is required to produce this result, or if such small amounts as are obtained in the customary methods of ozonising air by phosphorus are employed (1 to 3 m.grms. per litre), a large volume of ozonised air must be used, and a considerable interval elapse, before bleaching is effected.

The *Palmella cruenta* is a small alga much resembling clotted blood. Its colouring matter, *palmellin*, Dr. T. L. Phipson finds to closely resemble hæmoglobin. It is, like the latter, insoluble in alcohol, ether, benzol, sulphide of carbon, &c., but it dissolves in water. It is, further, dichroic; it is composed of red matter united to an albuminoid substance, and is coagulated by alcohol, acetic acid, and by the application of heat. Like the colouring matter of blood, it produces absorption-bands in the yellow part of the spectrum, though not exactly in the same position. Palmellin easily enters into putrefaction, giving off a strong ammoniacal odour, and, to complete its analogies with the colouring matter of blood, it contains iron.

M. Lami has investigated the comparative influence of milking twice or thrice daily. He considers the latter system, other conditions being the same, more favourable to the production of butter.

A correspondent of the "Chemical News" calls attention to the fact that during the past two years no less than eleven claimants for recognition as elementary substances have presented themselves in that journal, their names being Davyum, Neptunium, Lavoesium, Mosandrum, "New Earths," Philippium, Ytterbium, Decipium, Scandium, Norwegium, Uralium. While several names in this formidable list are, doubtless, destined to stand the test of time, the majority, it is thought, will have to join the noble army of "defunct elements." Probably only the "fittest" will survive. And the question is, what delay shall occur before mentioning these substances in the instruction of

advanced classes? What authority is weighty enough to settle the existence or non-existence of these bodies?

At a meeting of the Academy of Sciences, on September 1st, M. P. T. Cleve announced the discovery of two new elements in erbia, which he has named respectively *Thullium* and *Holmium*.

Herr Fleitmann conceived the idea that the brittleness of nickel and cobalt was due to absorption of carbonic oxide. He succeeded in removing it by the addition of small quantities of magnesium, obtaining both metals in a perfectly malleable and ductile condition. To prevent explosions, the magnesium is introduced through a hole in the lid of the crucible after the oxygen has been removed by the addition of fragments of charcoal.

A new method for the detection of arsenic has been devised by Prof. Selmi. The method is that of Schneider modified so as to incur no losses. The substance to be examined is treated with hot concentrated sulphuric acid, and during the same time is traversed by a current of hydrochloric acid gas, which carries with it all the arsenic in a state of chloride, separating it from the organic substances with which it was mixed. The arsenical liquid is then placed in a Marsh's apparatus and tested in the usual manner. Prof. Selmi has been thus able to obtain the metallic ring on operating upon 100 gms. of animal matter containing 1-400th of a milligrm. of arsenious anhydride.

Reichenbach's wood-tar colour Pittical has been resuscitated by A. Gratzel, and it is now an article of commerce at the price of £4 per kilo., under the name of "German-Imperial-Flower-Blue," with reference probably to the blue corn-flower, which is said to be the favourite cognizance of the German Emperor. The acetate is generally used for dyeing, dissolved in a little acetic acid diluted with water, and almost neutralised with ammonia. In this bath silk and wool take a fine reddish blue without the aid of any mordant. Cotton and other vegetable fibres are prepared with a solution of tannin, followed by a solution of tartar emetic. The colours produced are perfectly fast. From Reimann's "Farber Zeitung" we learn that if Pittical is separated from its alkaline salts, and heated with alcoholic ammonia in a sealed tube to 176°, a base is obtained closely resembling rosanilin in its composition. It dissolves in acetic acid with a corn-flower blue colour. The new colour is the first member of a new series of tinctorial products, which may prove of great importance.

Dr. Meusel, of Breslau, prepares colouring matter by treating coal-dust with nitric acid, or with a mixture of alkaline nitrates and sulphuric acid, or with other oxidising agents. A part of the coal is thus rendered soluble with a deep brown colour in alkaline hydrates or carbonates. The black residue serves as a body colour. The brown alkaline solution can (says

the "Die Allg. Polyt. Zeitung") either be used at once, or metallic salts of a black or dark brown colour may be precipitated from it, or the precipitate produced by the addition of acids may be used as a pigment.

According to the "Moniteur des Produits Chimiques," ostrich feathers are bleached in a bath of 10 grms. barium peroxide to 1 litre water, heated to 30°. In this they remain for forty-eight hours, and are then washed, treated with weak hydrochloric acid, and dried.

According to M. Moyret, 40,000 kilos. of copperas, pyrolignite of iron, and other iron mordants are used daily in the Lyon district for weighting black silks. For whites and bright shades sugar is used, to which the author proposes an addition of a decoction of quassia. Silk dresses thus prepared would serve for fly-papers! Stannic chloride, mysteriously spoken of in the trade as X, is employed in addition to sugar. Barium sulphate has also been proposed, but it deprives the silk of its lustre.

The following formula for preparing a mordant from lees of wine is taken from a recent number of "Chemiker Zeitung": — Fresh green lees, with the addition of two-fifths sodium tartrate, are evaporated down to one-sixth the original volume. 15 grms. of Cologne glue and 10 grms. tannic acid are added. The mass is pressed, rubbed over with alcohol and tannic acid, dried in the air, and powdered. For use it is to be further mixed with one-fifth per cent sodium tartrate. It is recommended for dying full shades in wool and silk, and is said to render the aniline colours permanent. In dying woollen cloth a decoction of Saponaria root is added both to the mordant and the dye-bath.

In a communication on the action of vinegar upon alloys of lead and tin Herr R. Weber shows that vinegar attacks pure tin as well as alloys with lead, the quantity of metal dissolved increasing with the proportion of lead present. Alloys of tin and lead, to which 4 per cent antimony had been added, were also attacked, and lead entered into solution.

Nickelising without electricity may be effected, says the "Moniteur Industriel," by introducing into a 5 or 10 per cent solution of zinc chloride as much of a salt of nickel as is sufficient to give it the ordinary colour of a nickel-bath. The articles to be coated, previously well cleaned, are laid in this solution, and the process is complete in from half an hour to an hour. Cobalt can be deposited in the same manner.

T. Troost has reported to the Société d'Encouragement pour l'Industrie Nationale on M. Gaiffe's Galvanic Deposits of cobalt. The metal is deposited from a solution of the double sulphate of cobalt and ammonia, and is superior to nickel at once in hardness, tenacity, and in beauty of colour. It is much less oxidisable than iron, but is very easily dissolved by acids.

From a report by M. Aimé Girard on M. Kuhlmann's (junior)

methods of conveying acids, we learn that M. Kuhlmann, in place of carboys, employs floating reservoirs in the form of an ordinary boat, fitted with air-chambers to give them sufficient buoyancy. For sulphuric acid of 60° B. and upwards these are constructed of sheet-iron, and have been in successful use for some years on the canals of the North. For hydrochloric acid he uses cylinders of hardened india-rubber, kept in their form by an external framework of wood. A modification of the structure serves for transport by rail.

The value of aluminium sulphate as a disinfecting agent is ascribed by A. Tedesco in "Die Chemische Industrie" to the following action:—The ammoniacal products of decomposition are fixed as ammonium sulphate; the liberated aluminium hydrate carries down all suspended particles, forming with them a solid precipitate. The organic cell, in contact with aluminous compounds, absorbs alumina with great avidity, losing thereby its vegetative power, and putting an end to the process of decomposition. Herr Tedesco considers bauxite and wochenite the best materials for the preparation of a sanitary sulphate of alumina. Kaolins are readily attacked by sulphuric acid, but are poor in alumina and comparatively costly.

The influence of the chemical composition of water in the preparation of raw silk is pointed out in a communication from the Instituto Technico Superiore of Milan. In silk are distinguished the soluble constituents, "varnish," or "gum" and colouring matters, and, on the other hand, the insoluble fibre. The soluble constituents give raw silk its brightness, colour, and strength, and should therefore be preserved as far as possible. For the purpose of unwinding the cocoons the natural gum should be softened, but not dissolved. According to Franceson, silk, if deprived of all its soluble constituents, loses at the same time its strength and elasticity. The authors of this paper find that though the loss of strength is proportional to the loss of soluble matter, the elasticity is but slightly diminished. In order to minimise the loss sustained in softening the cocoons hard waters are used, and soft waters are artificially modified by the addition of sulphate of lime and carbonate of soda. Silks which are to be dyed bright colours, however, should be spun out of soft water.

An improved device for testing petroleum oils, brought out by Mr. Holly, is described by "The Engineering and Mining Journal." With the common oil-tester it is extremely difficult, even for one skilled by long practice, to get reliable results except by taking the mean of a number of tests, since the approach of a jet of flame, however small, to the surface of the oil, as usually practised, destroys the accuracy of the test more or less, either by the local heating of the oil or by the production of disturbing air-currents. Mr. Holly modifies the apparatus usually employed by arranging the poles of a battery within

three-eighths of an inch from the surface of the oil, so that he is able to pass a spark between them, as the thermometer registers an increase of one degree in temperature. By this means the disturbing influences above noted are reduced to a minimum, and much greater accuracy in the results of such examinations is assured.

The Patents-Committee of the German Association for Promoting the Interests of Chemical Industry recently held a session at which an interesting communication from the scientific staff of the Baden Aniline Works was read. The authors point out that neither a novel substance nor a novel application of a substance obtained chemically can be patented in Germany. Concerning the preliminary investigation they doubt the possibility of deciding *à priori* on an invention.

Geology, Palæontology, &c.

The Memoirs of the Geological Survey, England and Wales, includes one on "The Geology of the N.W. part of Essex and the N.E. part of Herts, with parts of Cambridgeshire and Suffolk, by W. Whitaker, W. H. Penning, W. H. Dalton, and F. J. Bennett. The authors describe the cretaceous strata from the Gault to the Upper Chalk, the Eocene beds from the Thanet Sands to the London Clay, the Red Crag and the Glacial deposits of boulder-clay and gravel and sands. We notice that in a bed of so-called peat found in a cutting between Audley End and Saffron, in the valley of the Cam, two cart loads of large mammalian bones were taken from an area of 60 feet by 20. Some of them are the lower jaws of an ox, probably *Bos longifrons*. They bear artificially-made markings, and along with them was found a very fine horn of the Irisk elk, *Cervus Megaceros*.

The "Records of the Geological Survey of India" contain a translation of a paper on the geographical distribution of fossil organisms in India, read before the Imperial Academy of Sciences in Vienna by Dr. Waagen, formerly of the Geological Survey of India. The author considers that at the close of the Eocene epoch the sea retreated altogether from India; only in the neighbourhood of Karrachi and Arracan does it appear to have touched the Indian continent, so that the sea of the Miocene and Pliocene periods probably extended away to the southward, whilst a north-westerly connection of the continents probably took place with North Africa through Arabia. Blanford's supposition of an Indo-Oceanic continent uniting Africa, India, and Australia, and existing without important changes from the end of the palæozoic up to the miocene and pliocene periods, is thoroughly erroneous. A submerged forest has been discovered on Bombay Island, remarkable as showing that in recent or subrecent times a depression must have taken place in the immediate neighbourhood of ground which appears to have been raised.

Another number of these valuable "Records" contains an interesting discussion on the origin and affinities of a fossil jaw, found in the Sivalik range, which is referred to a new species, *Palæopithecus sivalensis*. It was intermediate in size between the mias and the gorilla, but in dentition falls between the chimpanzee and man. The author considers that its occurrence is another piece of evidence in favour of the hypothetical sunken continent Lemuria, from which the anthropoids have been dispersed. He suggests that the unexplored tertiaries of Africa, Sumatra, Borneo, and Southern India may probably contain forms bridging the chasm between the highest-known apes and man. In the same district proof has been obtained of the former existence in India of an emeu double the size of the existing emeu of Australia. *Megaloscelornis sivalensis* was a wader probably allied to the adjutant crane, but in stoutness and length of limb approaching the ostrich. Colonel C. A. MacMahon contributes some interesting notes on the supposed glaciation of India. He finds the contour of the hills and valleys in the interior Himalayas sharp and angular, rounded outlines, where seen, being sufficiently explained by the action of sub-aërial forces on comparatively soft and friable rocks. The idea of an ice-cap is thus set aside, and there seems even no evidence that the existing glaciers had ever, within a reasonable geological period, extended lower than 11,000 feet above the sea-level. Mr. Lydekker, in his investigations in the valley of Kashmir, finds no evidence in favour of a former glaciation of the outer hills and the Upper Punjab.

From a memoir on the "Geology of the Salt-Range in the Punjab," by Mr. A. B. Wynne, we learn that the rocks of the salt-range comprise alternations of calcareous, earthy, and sandy deposits, which may be arranged under thirteen main divisions. Nine of these can be referred to as many of the main formations recognised by geologists, whilst the ages of the other four are not satisfactorily determined. The economic resources of the district have been exaggerated. The deposits of salt, indeed, are enormous, and the average annual receipts from their working reach the sum of £388,144. Still we must remember that the world's available supplies of this mineral are incalculably in excess of any conceivable demand for ages to come. In the so-called Mayo mine a pink-coloured salt has been found containing 61 per cent. of potassium chloride, but unfortunately it formed merely a local lenticular deposit, and Mr. Wynne has not been able to detect it in other parts of the range. The coal found in the region is pyritic, shaly, and not very abundant. Sulphur occurs in exceedingly small quantities. Petroleum wells are not copious, a gallon daily being considered a good flow. Sandstones, saturated with oil, are abundant, and might, doubtless, be profitably distilled. The stream-gold yields a scanty return, 4 annas' worth being the average per man for a day's washing.

Copper occurs as a mineralogical curiosity only. Galena is found in small disseminated crystals in the dolomite of Karangli. Iron ores of a first-rate kind are mentioned by Mr. Powell and Dr. Henderson as having been obtained from the Korana hills, but the cost of production would not be remunerative owing to the scarcity of fuel.

The Daltonganj and Aurunga coal fields may, according to the estimate of Mr. V. Ball, F.G.S., yield 30 million tons of coal of a good quality. In this estimate the Singra seams are not included, though it is remarked that they might be profitably worked for some years as open quarries. Concerning the Hutar fields, the author considers that any estimate would be premature, as the lateral extension of the seams is quite unknown. Concerning the Tatapani coal-field nothing definite appears to be known. Iron ores of different kinds, magnetite, carbonate, and carbonate altered into hæmatite appear to be found in considerable quantity, but under circumstances which make their utilisation a somewhat problematical question. The limestone of the region is, however, well adapted for use as a flux. Galena and copper ores occur, but, it would seem, not in quantity.

A recent issue of the "Geological Survey of Canada" contains a paper "On the Fossils of the Cretaceous Rocks of Vancouver and adjacent Islands in the Strait of Georgia," by J. F. Whiteaves, F.G.S. The palæontological researches of the author support the conclusion of Mr. Gabb, based upon an investigation of the cretaceous fauna of California, that a continuous land-barrier between the oceans of that period can scarcely be admitted. The respective faunæ of the Upper Cretaceous of Vancouver and of Texas are even more closely related than those of the same period in California and Texas.

The American Association for the Advancement of Science held its twenty-eighth meeting at Saratoga Springs, N.Y., beginning August 27th, 1879. The meeting was a memorable one, both on account of the large attendance and the great value of the papers presented. The Association was honoured by the presence of an unusually large number of its ex-Presidents, no less than nine being on the platform at one time. The presiding officer, Prof. George F. Barker, M.D., of the University of Pennsylvania, was very happy in conducting the business of the Society, his genial humour in no wise detracting from the dignity of the occasion, and serving as a pleasant refreshment. The other officers of the Association were as follows :—Vice-President of the Physical Section, Prof. S. P. Langley, of Alleghany, Pa. ; Vice-President of the Natural History Section, Major J. W. Powell, of Washington, D.C.; Permanent Secretary, Prof. F. W. Putnam, of Cambridge, Mass. In the absence of Dr. George Little, of Atlanta, Ga., Dr. H. Carrington Bolton, of Hartford, who was General Secretary at the St. Louis Meeting (1878),

was continued in office. The Chairman of the Sub-section of Chemistry, Dr. Ira Remsen, of Baltimore, was, unfortunately, prevented from attending, and Prof. F. W. Clarke, of Cincinnati, took the position. One of the features of these meetings is the address of the Retiring President. On this occasion Prof. O. C. Marsh, of New Haven, had the duty to perform. His subject was "The History and Methods of Palæontological Discovery." Vice-President Langley gave an address on "Solar Physics," a subject to which he himself has materially contributed. And Major J. W. Powell gave an address on "Mythologic Philosophy, having special reference to the mythologies of the Indian tribes. Dr. Ira Remsen's address was a plea for the study of Organic Chemistry, a branch which he claims is too often neglected in the courses prescribed in colleges and scientific schools. These addresses will appear in full in the annual volume of Proceedings. Heartily welcomed by the meeting was the distinguished astronomer, Dr. Otto Struve, Director of the Pulkowa Observatory, Russia, who is in America for the purpose of securing a larger object lens for a refracting telescope than has yet been made in the world. The lens is to be made by Alvan Clark and Son, of Cambridge, Mass. The lion of the gathering was, undoubtedly, Dr. Thomas A. Edison, of Menlo Park, N.J. He exhibited on Saturday evening, to a delighted audience of 1500 persons, his recently-invented Electro-Chemical Telephone. Speech, music, &c., was transmitted from a distant room, and the sounds issuing from the telephone were heard by every individual in the hall. Perhaps the most remarkable discovery announced is one by Dr. Edison, which will necessitate an entire revision of the physical constants of all known metals. His paper was entitled, "The Phenomena of Heating Metals in Vacuo by means of an Electric Current," and demonstrated that platinum heated *in vacuo* by electricity becomes denser, harder, more infusible, and less liable to disintegration when heated in a flame. Iron treated in a similar manner becomes as hard as steel and just as elastic. Aluminium melts only at a white heat.

The Meeting of the French Association for the Advancement of Science for 1879 was held, in August, at Montpellier, under the presidency of M. Bardoux, the late Minister for Public Instruction. The speaker chose for his subject "Education," viewed chiefly from a literary and a moral point of view. Still he declared that "henceforth the memory must no longer be made the basis of education." He denounced the too great importance attached to words, and quoted Montaigne to the effect that the pupils of many pedagogues were simply "asses loaded with books." The financial statement showed that the capital of the Society amounts to about 300,000 fr. The grants for research last year amounted to 10,000 fr. One of the lectures was given by M. Denayrouze, on "The Progress of Electricity."

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M. Barral, Perpetual Secretary of the National Society of Agricure, also delivered a lecture on "The Use of the Rhone Water for Irrigation." The meeting for 1880 will take place in Rheims, in the month of August, while it has been decided to hold the meeting of 1881 at Algiers, during the month of April. For this meeting M. Chauveaux, Director of the Veterinary School of Lyons, has been elected the President. Among the papers read before the Chemical and Physical Sections were: "On the Compound Ammonias," by M. Buisine; "On the Oxidising Action of Cupric Oxide," by M. Cazeneuve; "On the Determination of Methylic Alcohol in Ethylic Alcohol," by M. Caillol; "On the Calcareous Soils of Barcelona, from a Chemical Point of View," by M. Luis Cabello e Ibanez; "On the Emissive and Absorbent Powers of Flames, by M. Rosetti; "On a Compass for the Measurement of Powerful Currents," by M. Ducrétet; "On the Method of Measuring the Intensities of the Currents of Bunsen Batteries by means of Thomson's Galvanometer," by M. Mercadier; and "On Thermometric Measurements of High Temperatures," by M. Crova.

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